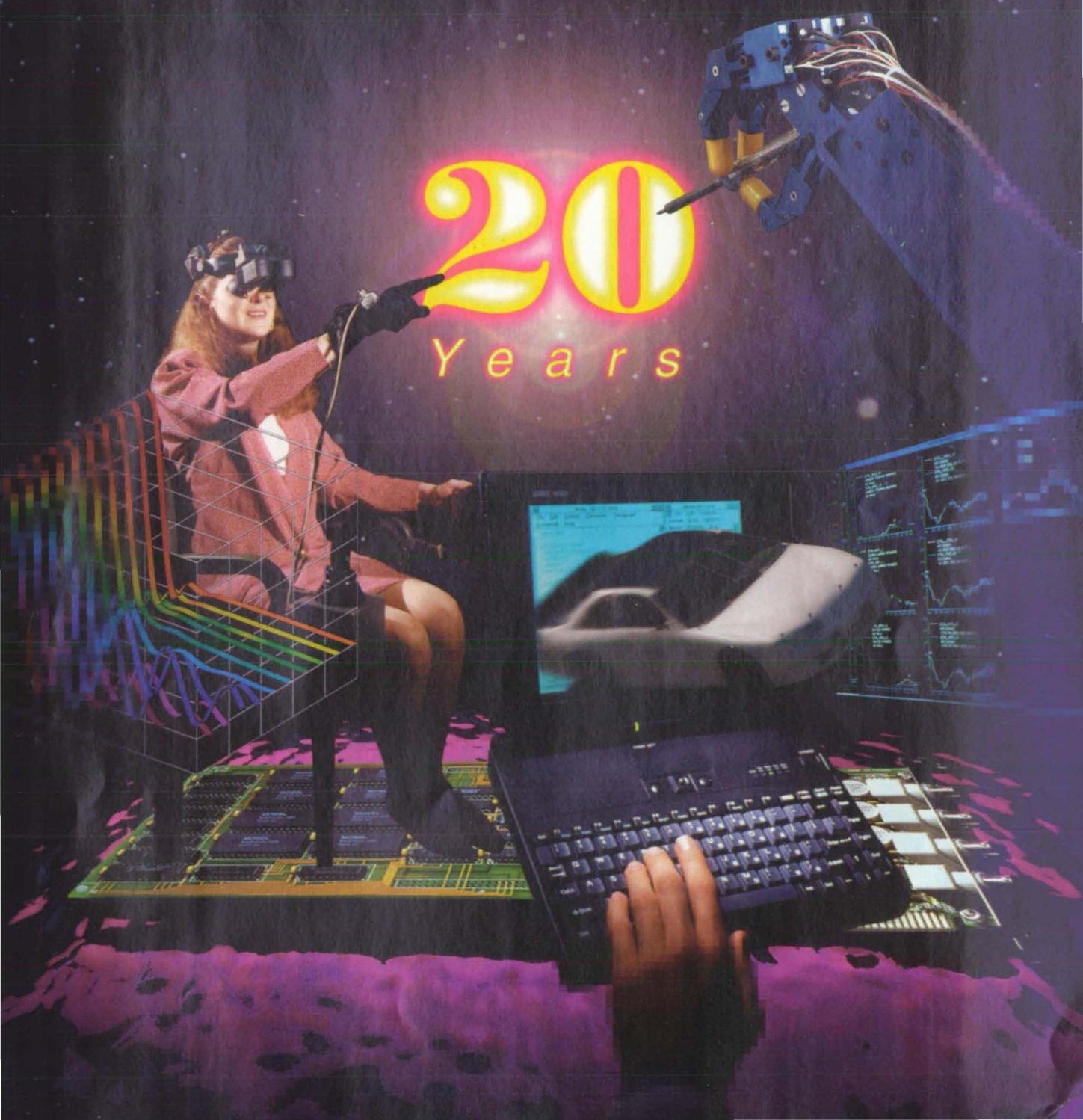




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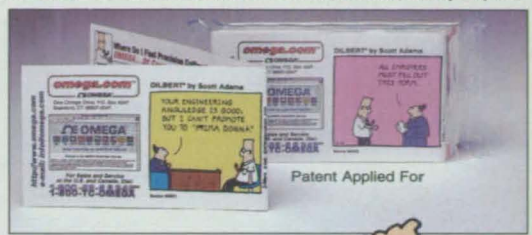
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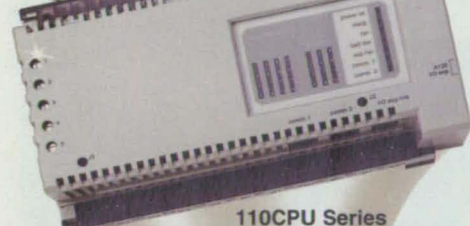
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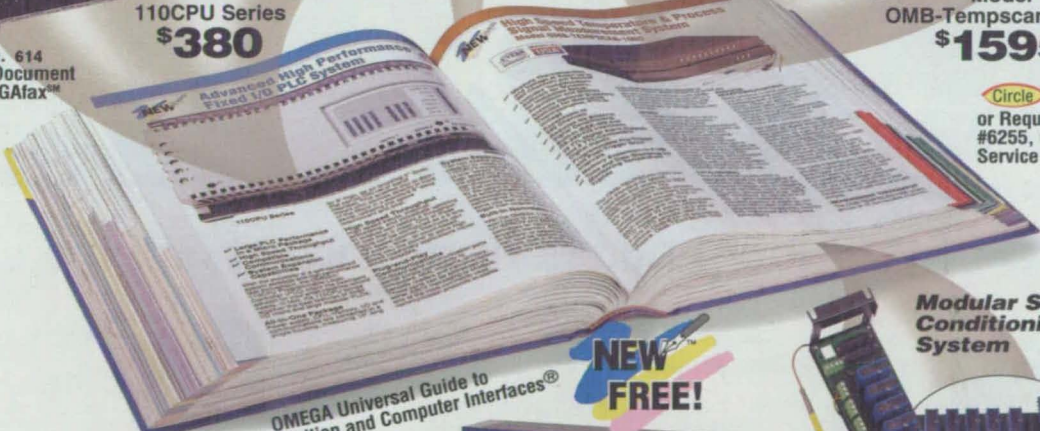
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This month, NASA Tech Briefs celebrates its 20th year as a magazine. Since publication of the first issue in the Spring of 1976 (pictured here), NASA Tech Briefs has highlighted more than 12,000 commercially viable NASA technologies for transfer to the engineering community. Many of those technologies resulted in products and processes currently used by millions of Americans, both at home and in industry. A sampling of those important innovations is depicted on the cover of this special 20th anniversary issue. (This issue's cover image manipulation and photo montage by Martin Ingber.)

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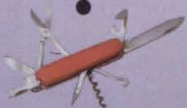
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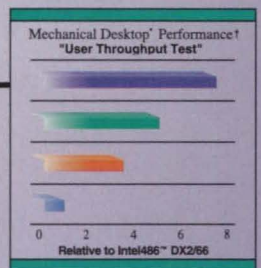


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Publisher Joseph T. Pramberger
Chief Editor Linda L. Bell
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BRIEFS & SUPPORTING LITERATURE: Written and produced for NASA by
Advanced Testing Technologies, Inc., Hauppauge, NY 11788

Technical/Managing Editor Ted Selinsky
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NASA Tech Briefs are provided by the National Aeronautics and Space
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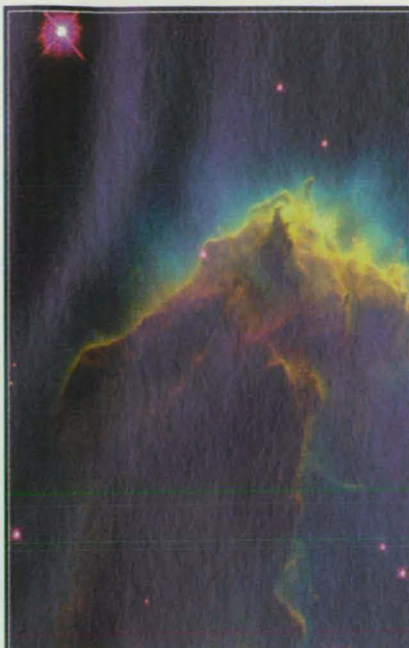
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These spectacular images were captured by the Hubble Space Telescope and processed, viewed and analyzed in IDL.

fuzzy pictures big problem

The Hubble Space Telescope is in orbit when a defect is discovered in the primary mirror. Fuzzy pictures. Big problem.

Scientists knew they faced a daunting task when they launched the servicing mission to repair NASA's Hubble Space Telescope in 1993. They needed superior software tools to test, calibrate and analyze the data from the replacement camera. They chose IDL, the *Interactive Data Language*.

Here's why.

The ability to quickly and easily write applications, compile data and visualize results compelled the Investigation Definition Team for the WFPC-2 to use IDL as their software language. IDL provides a "powerful, flexible language that is easy to use and customize," says Paul Scowen, a team member. "With IDL you can be productively working on your data after only a couple days' exposure to the environment."

IDL helps make Hubble picture perfect

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"Among other things, I put together a GUI that incorporated numerous IDL applications in a simple, point-and-click mode. IDL is one of the best environments I've seen to design GUIs quickly and easily," says Scowen.

Scowen estimates they saved "more than a year of labor over the course of three years by adopting IDL over other alternatives." Because IDL runs on Windows, Unix and Macintosh computers, the team could quickly and efficiently share their work. "Being able to take procedures written on one machine and directly transplant them to another at the drop of a hat is particularly advantageous," Scowen says.

"Many of IDL's array-handling logic routines are invaluable," Scowen adds. "For example, the ability to multiply two arrays in memory as fast as IDL does cannot be matched by other commercially-available software."

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For More Information Write In No. 685

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center

Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Syed Shariq
(415) 604-1919
syed_shariq@qmgate.arc.nasa.gov

Goddard Space Flight Center

Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gscf.nasa.gov

Johnson Space Center

Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@jp101.jsc.nasa.gov

Langley Research Center

Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6005
j.s.heyman@larc.nasa.gov

Marshall Space Flight Center

Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(205) 544-5419
harry.craft@msfc.nasa.gov

Dryden Flight Research Center

Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
duke@louie.drrf.nasa.gov

Jet Propulsion Laboratory

Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
James Rooney
(818) 354-2240
james.a.rooney@jpl.nasa.gov

Kennedy Space Center

Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Bill Sheehan
(407) 867-2544
billsheehan-1@ksc.nasa.gov

Lewis Research Center

Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Ann Heyward
(216) 433-3484
ann.o.heyward@lerc.nasa.gov

Stennis Space Center

Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Anne Johnson
(601) 688-3757
ajohnson@wpogate.ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional technology Transfer Center nearest you, call (800) 472-6785.

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NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at <http://nctn.hq.nasa.gov> to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center**, (505) 277-3622. For software developed with NASA funding, contact **NASA's Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: <http://www.cosmic.uga.edu> or service@cosmic.uga.edu.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

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gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Karen Robbins
American Technology Initiative
Menlo Park, CA
(415) 325-5353

John Gee
Ames Technology Commercialization Center
Sunnyvale, CA
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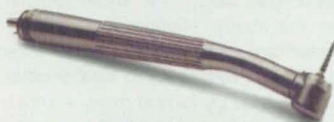
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PATENTS NASA

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Digital Parallel Processor Array for Optimum Path Planning

(U.S. Patent No. 5,548,773)

Inventors: Sabrina E. Kemeny, Eric R. Fossum, and Robert H. Nixon, Jet Propulsion Laboratory

The invention is a method of path planning across terrain using a digital parallel-processor array in an integrated circuit chip. Each processor is assigned a value representing the difficulty in traversing that portion of the terrain, and a corresponding delay—the more difficult, the longer the delay. Neighboring cells in the processor are connected by links extending along different directions to one another. The device operates by having many stimulus signals electronically travelling all possible paths simultaneously between two chosen points, detecting the first-to-arrive signal and determining which path it followed. The signals emanate from a single starting point and provoke each node or cell in their paths to broadcast copies of each arriving stimulus signal to all adjacent nodes, until every one in the array has received a stimulus signal. Each node blocks the arrival of all but the first-to-arrive stimulus signal and remembers the direction from which that signal arrived. Thus the invention simultaneously constructs the easiest paths to all nodes in the array from the starting node.

For More Information Write In No. 776

Apparatus and Method for Cold Welding Thin Wafers to Hard Substrates

(U.S. Patent No. 5,549,237)

Inventors: Richard C. Oefftering and Floyd A. Smith, Lewis Research Center

In cold welding, pressure is applied to the parts to be joined, causing plastic deformation at the surfaces and, ideally, interatomic bonds. Thin films of a common metal on such surfaces can be forced together to create a joint that is strong structurally but also so thin that it has negligible effect on the transmission of acoustic waves. But the film materials used, particularly indium, require that joining take place in a vacuum. This apparatus and method for coating and bonding a pair of metal or non-metal parts uses a floating mount assembly for holding one of the parts and for providing a spring-biased bonding force to them in the vacuum chamber. A pivoting mount assembly holds the other part. In the coating position, both assemblies orient the bonding surfaces in the same direction for coating. Then the pivoting assembly is rotated so that the bonding surfaces face each other. The floating block assembly uses a purely mechanical form of energy storage to apply bonding force, eliminating hydraulic systems that could contaminate the chamber.

For More Information Write In No. 778

Bending and Torsion Load Alleviator with Automatic Reset

(U.S. Patent No. 5,558,182)

Inventors: Horacio M. de la Fuente, Michael C. Eubanks, and Anthony X. Dao, Johnson Space Center

A problem with load alleviators designed to protect a joint or component against excessive torsional and bending forces has been that they do not dissipate a significant portion of the energy input from one component to another, and significant energy is present when the components return to their original configuration once the load is removed. This alleviator uses a spring strut structure to dissipate excessive input forces, a structure that also returns the components to their original configuration with a low energy once the excessive load is removed. The invention comprises a crown assembly with cam surfaces circumferentially spaced about a portion of it, a center housing whose end portion is engageable with the crown assembly and has cam followers for engaging the cam surfaces, and the energy dissipator whose elongate member is axially movable within its body.

For More Information Write In No. 777

Unipolar Terminal-Attractor-Based Neural Associative Memory with Adaptive Threshold

(U.S. Patent No. 5,544,280)

Inventors: Hua-Kuang Liu, Jacob Barhen, Nabil H. Farhat, and Chwan-Hwa Wu, Jet Propulsion Laboratory

One of the major applications of neural networks is in the area of associative memory. The work of Hopfield initiated intense interest in such networks, but the storage capacity of the Hopfield model proved quite limited. To alleviate the spurious-states problems in this model, the concept of terminal attractors was introduced by M. Zak. But the improvement of the storage capacity of the Hopfield model by the terminal attractor cannot be determined based on Zak's model. The present patent presents a unipolar terminal-attractor-based neural associative memory (TABAM) system. By adaptively setting the threshold values for the dynamic iteration for the unipolar binary neuron states with terminal-attractors for the purpose of reducing spurious states, and using the inner-product approach, perfect convergence and correct retrieval is achieved.

For More Information Write In No. 779

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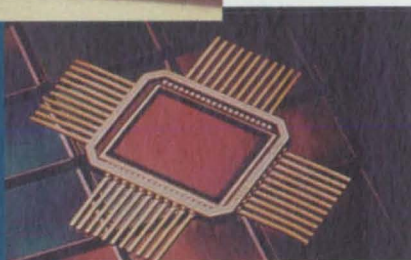
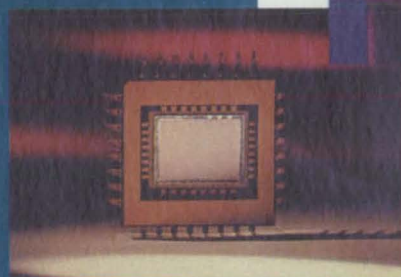
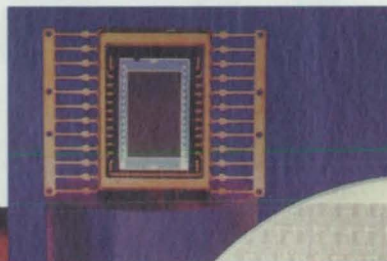
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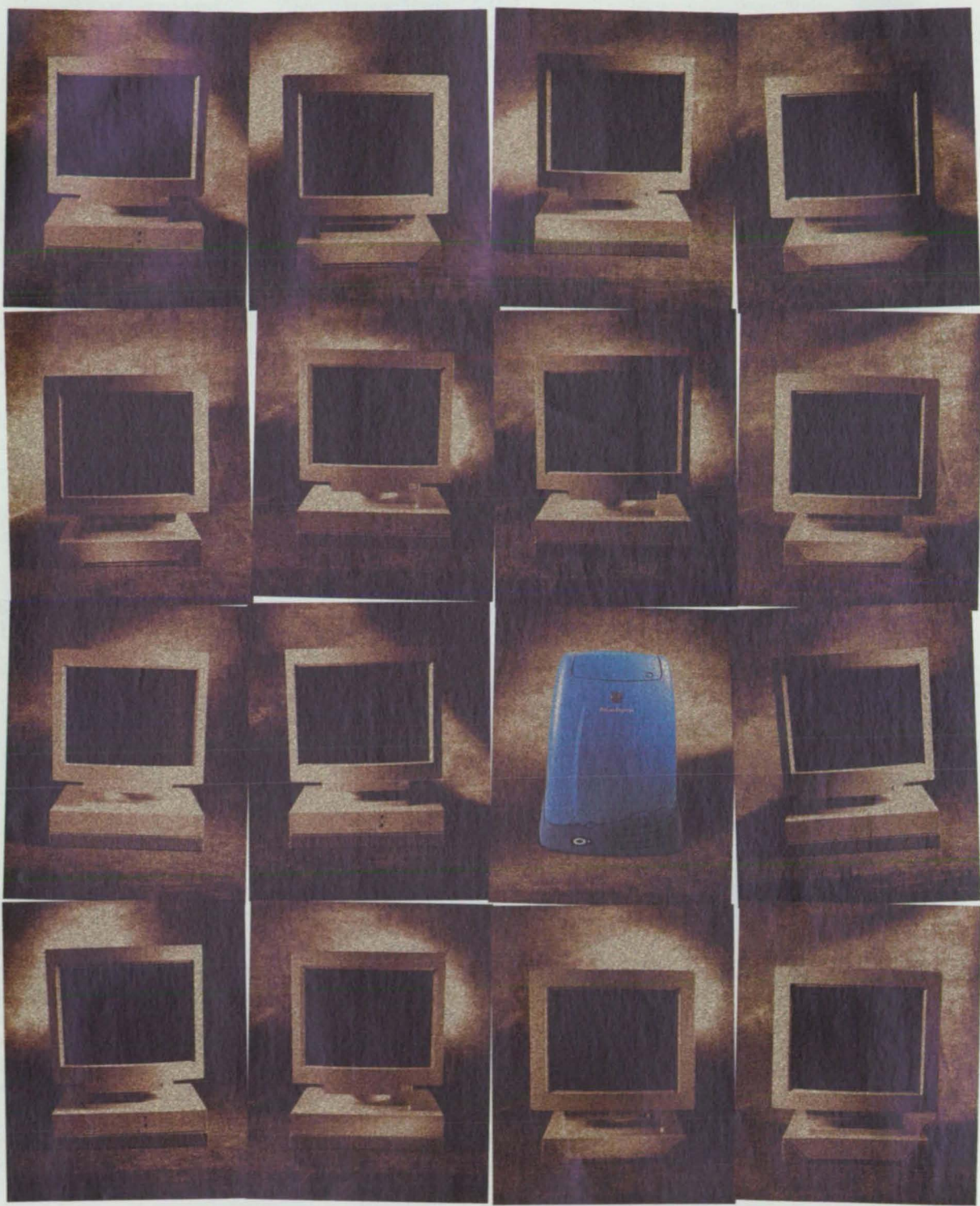
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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page

in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting

the TSP referenced at the end of the full-length article or by writing the Commercial Technology Office of the sponsoring NASA center (see page 14).

Microstrip Reflectarray Antennas With Mechanical Phasing

These antennas would weigh less and have lower profiles than paraboloidal models, which would make them

more practical for mounting on vehicles and buildings. Beam steering, like phased-array models, would be operated without mechanical rotation of the entire structure. (See page 54.)

Superconducting Notch Filter for 171 MHz

This band-stop filter was constructed to demonstrate the utility of high temperature superconductor films on sapphire. The objective is to improve miniaturization and performance of narrow-band filters for various communication systems. (See page 56.)

Reducing Leakage Currents in a Bipolar Battery

In this proposed design concept, the cells would share electrolyte and gas via an intrabattery manifold. The shape and dimension of the manifold would be chosen to maximize electrical resistances and thus minimize leakage currents. (See page 60.)

Neural-Network Guidance System for a Mobile Robot

An electronic sensing and control system is being developed for use in guiding a mobile robot through hallways and rooms in a building. The project is part of a study of interactions between humans and robots in an office environment. (See page 62.)

Membrane Modules Separate Nitrogen From Carbon Dioxide

The conversion of carbon dioxide to oxygen in air-revitalization systems is facilitated by removal of excess nitrogen. Such modules could also be used to remove carbon dioxide and hydrogen sulfide from natural gas and to concentrate carbon dioxide from flue gases. (See page 72.)

Visual Indicator of Filter Exhaustion

Filters used to remove volatile organic compounds from air can use a visual indicator to show saturation. Maintenance people would not have to open the filter and expose themselves to gases. (See page 76.)

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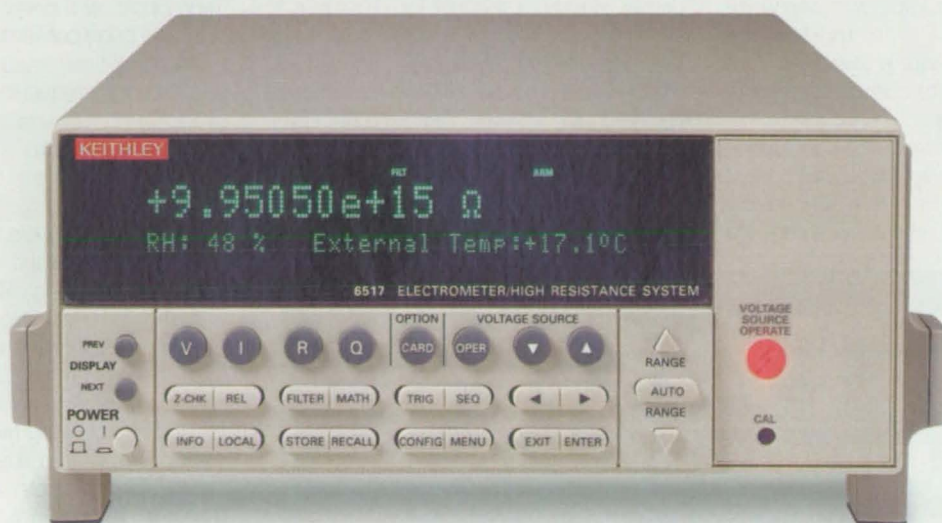
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• Amps	2nA – 20mA	10fA – 100nA	0.1% – 0.2%
• Ohms	2M Ω – 200T Ω	10 Ω – 1G Ω	0.125% – 1.15%
• Coulombs	2nC – 2 μ C	10fC – 10pC	0.4%
• V Source	100V – 1000V	5mV – 50mV	0.15%

Notebook

Welcome to the 20th Anniversary issue of *NASA Tech Briefs*. *NASA Tech Briefs* began in 1962 with one white paper, which grew into more white papers, until there was a steady stream and NASA decided to compile them into a quarterly magazine.

Eight years after that first issue (Spring 1985), NASA – then, as now, under budget pressure – needed to find a way to cut costs. The idea of commercializing the

magazine seemed the best solution, and under the leadership of Administrator James Beggs, a request for proposals to commercialize the magazine was sent out. We, Associated Business Publications, were chosen to be NASA's commercial partner in the first-ever joint venture in periodical publishing by a government agency and a private-sector publishing company. The idea was to recoup all printing and postage costs heretofore covered by NASA

through the sale of advertising. NASA would pay us no money to publish *NASA Tech Briefs*, and never has in the 11 years we have been publishing the magazine.

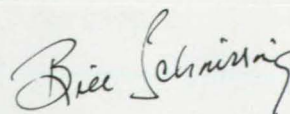
As long-time readers know, we increased the frequency of the magazine gradually from quarterly to monthly, and the circulation rose from 70,000 with a waiting list of 15,000, to the more than 200,000 subscribers, and overall approximately 500,000 readers, we have today. *NASA Tech Briefs* is now the world's largest BPA-audited engineering magazine.

Along with retaining its original mission as an awareness and problem-solving tool, the magazine continues to explore and expand its capabilities as a medium for commercializing NASA technology. In 1990, we initiated the Technology 200X series. Our seventh annual technology transfer exposition and symposium, Technology 2006, just concluded at the end of October in Anaheim, CA, with NASA Administrator Daniel Goldin giving the keynote address. The total attendance exceeded 6,000.

In the 11 years that we have been publishing *NASA Tech Briefs*, we've saved \$20,000,000 in printing, paper, and postage costs previously covered by taxpayer dollars, thanks to you, the readers. We really appreciate your support and we thank our advertisers, who made this issue our largest ever.

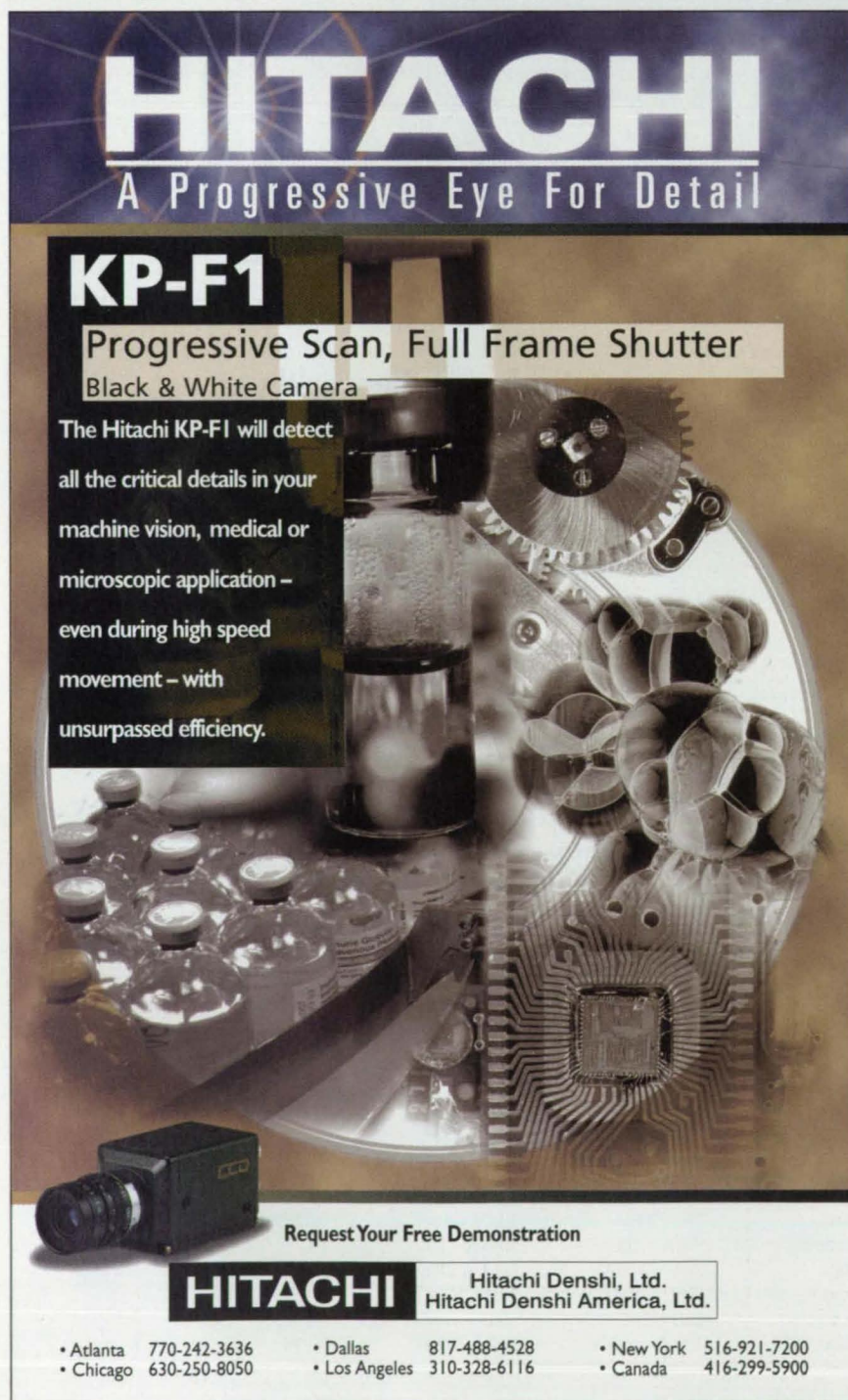
When one publishes a magazine, the logo is a crucial element in name recognition both for readers and in advertising sales. The logo for *NASA Tech Briefs* has been the same since its inception...the stylized typeface to which we're all accustomed. Publishers are loath to change logos, but since NASA has returned to their original logo as their official logo, it seemed that this 20th Anniversary issue would be an excellent time for us to make the change as well.

As always, we value and seek your opinions. Any comments you wish to make to me are not only appreciated, but sought. One of my e-mail addresses is: abp1@mail.idt.net. I'd be delighted to hear from you.



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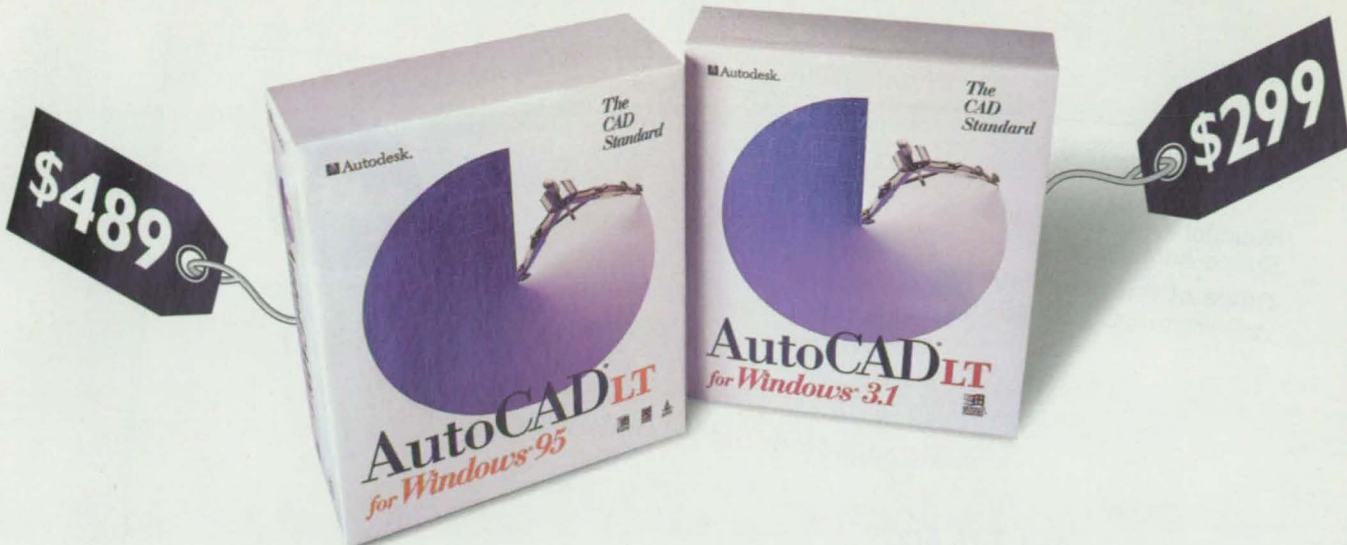
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A Message from the Administrator

20 Years of *NASA Tech Briefs*

NASA continues to focus on its contribution to the nation's future. NASA's mission is to be at the forefront of exploration and science and a leader in scientific discoveries and technological developments.

It is through the transfer of these discoveries and technological developments that NASA is able to share the wealth of our technology with the American people, the nation's research community, and U.S. companies. This, in turn, keeps them competitive in the world marketplace.

In the spring of 1976, *NASA Tech Briefs* began as a government-funded publication printed and distributed by the U.S. Government Printing Office. But through the imagination of its former Editor-in-Chief, Bill Schnirring, *NASA Tech Briefs* evolved from a black-and-white circular of sparse abstracts and diagrams into a full-color magazine with a growing circulation, currently at more than 215,000.

Today, as we celebrate 20 years of *NASA Tech Briefs*, I offer my congratulations to *NASA Tech Briefs* for effectively transferring information to the research community and industry ... all to the benefit of the American people.

A handwritten signature in black ink, reading "Daniel S. Goldin".

Daniel S. Goldin
Administrator

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Has It Changed Your Life Yet?

20th Anniversary Contest Highlights the Write Stuff

This month, NASA Tech Briefs celebrates a milestone – our 20th anniversary as a magazine. Over the past 20 years, more than 12,000 tech briefs have been published, generating nearly 1.8 million requests for Technical Support Packages. Today, more than 207,000 subscribers (and double that number in total readers) learn about NASA's technologies for transfer to the engineering community through the pages of NASA Tech Briefs.

We announced in June our 20th Anniversary Letter-Writing Contest, focusing on the impact NASA Tech Briefs has had on you — our readers. We were overwhelmed by the importance you placed on the role of the magazine in both your lives and your work. Many of you told us of specific instances

in which a brief or Technical Support Package provided a solution to a particular problem faced in the course of your job. Others related how the magazine served as a thought-provoking tool to stimulate creativity. And some of you shared with us your personal experiences of how medical innovations described in NASA Tech Briefs helped improve the quality of your lives.

Unfortunately, we were only able to name three Grand Winners and five Finalists out of the many impressive letters we received. The three winning letters are reproduced here, along with comments from the five finalists and many other entrants. Although we can't award 207,000 prizes, we think of all our readers as winners, and thank those of you who participated in the contest.



Grand Winners

Since its formation in 1958, NASA has placed Americans on top of not only science and technology, but the world. While the core foundation of NASA has rested upon space and aeronautics, allowing our nation to pioneer the furthest reaches of our environment while setting foot on our nearest neighbor, the organization has evolved immensely. In addition to fantastic achievements and present pursuits, NASA has established a process by which industries of nearly all aspects and interests may benefit from NASA-supported activities.

Stavatti Corporation is a rare case. While many firms undoubtedly benefit from NASA's technology transfer initiatives, few maintain a high regard for the interests that make NASA an extraordinarily unique institution: aeronautics and space. As a burgeoning aerospace firm, Stavatti is committed to aeronautics and space-related products. Presently pursuing the development and production of aircraft ranging from single-engine, general aviation airframes to multi-role fighters, Stavatti requires a variety of information sources.

Stavatti has benefitted tremendously from opportunities presented within every issue of *NASA Tech Briefs*. Since initiating our subscription nearly two years ago, *NASA Tech Briefs* has granted Stavatti innovative solutions through articles, Technical Support Packages, and COSMIC-issued software.

A very large array of NASA information has been obtained and applied by Stavatti. During these past two years, Stavatti has pursued a variety of endeavors, each of which consists of multiple individual projects. Be it the formation of composite structures, the integration of a flight computer, the measurement of an air intake's pressure recovery, the estimation of turbulence, or an improvement in aircraft maneuverability at high AOA, Technical Support Packages have provided an insightful grasp of the vast investments NASA has placed in varied studies which expand horizons of both knowledge and industrial possibility.

Numerous instances exist whereby technologies featured in *NASA Tech Briefs* have solved or are in the process of solving specific problems. Most recently, the concept of propellers and fans based on the Mobius Strip (July 1996) has generated tremendous interest. With the standard, constant-speed aircraft propeller remaining virtually unchanged for nearly 60 years, the thought that aircraft may be more efficient through applying an extraordinary concept is invigorating, serving as a prime example of how *NASA Tech Briefs* has improved our vision.

While further noteworthy Tech Briefs dividends come to mind, the advertising platform provided is nearly as important as research results. From state-of-the-art software to latch producers, a cornucopia of companies is provided within every issue. Stavatti has acquired many featured products, including FEA packages and advanced composites. In conjunction with *NASA Tech Briefs*, the Technology 2005 exposition provided the impetus for Stavatti to establish agreements with power plant suppliers, material processors, and subcomponent assembler alike, while forever refracting how we see aircraft canopies.

As its predecessor, NACA, which produced aerodynamic information dear to Stavatti, *NASA Tech Briefs* has provided a means by which the outcome of research may result in spinoffs down many roads, be it the highway where cars find greater efficiency, or the shopping aisle where mothers find Tang.

Christopher R. Beskar
Stavatti Corp.
Eagan, MN

The advances of humanity are like stones tossed into a pond – explosive advances from an idea whose time has come, followed by a series of ripples as that idea spread around the world. The steam age was born by a revolutionary idea, and the ripples spread as that idea was applied around the world. The same was true of the industrial age, the space age, and now the information age. Many times such ripples found fertile ground for other uses which the original inventor never imagined. The first steam engines were used to pump out mines; later they were applied to boats, trains, other power plants, adapted into steam turbines, even turbine-powered Indy race cars, and possibly for space applications. Such is the power of synergy and adaptability. Such is the power of spinoffs illustrated by space age answers laterally jumping to solve dilemmas in other fields.

In all the ages, the fact that knowledge is power has proven itself over and over again. In companies around the world, the visionaries of tomorrow have worked to turn their dreams into realities. In the two decades I have been reading *NASA Tech Briefs*, I have witnessed some of these brightest of visionaries. They have opened their DaVinci notebooks, displayed their Michelangelo drawings and sculptures, shared their Einstein theories for all the world to see.

Every year in the companies I have worked for, we have pushed the envelope: in aircraft, medical devices, spacecraft, power supplies, radar, fuel systems, control systems, and submarines. Many of these advances have come from the pages of *NASA Tech Briefs*; directly, from new materials, advanced composites and plastics, sensors, computer hardware and software, and electronics; and indirectly, from new theories, methodologies, and approaches. Further, I know that no one would claim we have reached the end of advances in any of these companies. We look forward to seeing the advances in the areas I have already mentioned. Furthermore, we look for advances that will drive innovations in lasers, optics, manufacturing and fabrication, robotics and automation, biomedical, and CAD/CAE during the next two decades.

Even in times of tight budgets can any company in America afford to neglect the free research and development of ten separate NASA Tech Service Centers. Even in times of tight budgets, we have always sent someone to the Technology 2000 national technology transfer conferences and the benefits have lasted throughout the year and beyond. Although our department has never formed partnerships or licensed NASA technologies, we could not have advanced as rapidly as we have without the information from the Technical Support Packages.

I have seen companies flourish because of the collective intelligence of its people. This collective intelligence forged with new information and knowledge – for instance, from *NASA Tech Briefs* – causes innovation to flourish. This growth in innovation causes companies to flourish. It's a simple equation. It's a self-evident answer for American companies facing a world of competition.

Chet Novak
Simsbury, CT

Visual perception is one's sense of spatial reality. Without vision there can merely be the graze of a presence that is lacking in form. It was during Technology 2005 that this became dramatically apparent to me. Moderating two Power and Energy sessions made me embarrassingly aware of what losing a small portion of one's vision can do. While reading speaker introductions, I found myself stumbling over unfamiliar technical terms, due to a vision impairment (maculopathy), with which it is possible to see only part of a word at a glance. Fortunately, there was help to be found at a NASA Technology 2005 exhibit. Technologies Benefiting People with Disabilities showed a way to overcome this: the Low Vision Enhancement System (LVES) developed by NASA and now being manufactured by the Visionics Corporation of Golden Valley, MN.

Many now using the LVES portable prosthesis are able to do productive and competitive work alongside their colleagues. It has since been further embellished by a system that maps sensed images onto what remains as usable field on the retina. An article, "Patterned Video Sensors for Low Vision," which appeared in *NASA Tech Briefs* (May 1996), described this project. The development of a prosthesis using non-Cartesian patterns of photoreceptors is further portrayed in NASA's Technical Support Package from that brief.

Having studied the support package, I came upon an idea that could help ophthalmologists diagnose and follow maculopathy development, and to prepare photoreceptor patterns for a visual prosthesis. Using my electronic-imaging engineering background, I was able to devise a cathode ray tube (CRT) visual tester that would show an ophthalmologist the shape, placement, and intensity of blind spots located on a patient's retina. This is something only a patient can see, and the CRT tester brings it more perceptibly to the patient's awareness. The patient, having delineated this information, allows a doctor to diagnose, trace maculopathy development, and prescribe a suitable prosthesis when laser treatment is not an option.

My own ophthalmologist is presently judging the feasibility of the first sample of the CRT tester, and upon this evaluation, a pilot run of CRT testers will be manufactured for other ophthalmologists to use and assess. A return of pliable vision to heretofore productive workers looms on the horizon, thanks to licensed NASA technology, *NASA Tech Briefs*, Technical Support Packages, and the Technology 2000 national conferences. Many technological advances such as this surely will follow those who read *NASA Tech Briefs*, as I have been doing for the past 15 years.

Roy L. Ruth
Dotronix, Inc.
Eau Claire, WI

Finalists

"The major influences from *NASA Tech Briefs* stem from the computer programs and electronic components and circuits presented monthly. Device fabrication and processes have played a major role in my career and generated unprecedented freedom in selecting simulation and building blocks for better designs. We have all benefited from the wealth of knowledge written in these publications. The helmet my daughter uses while riding her bicycle evolved out of the work of NASA scientists. The vehicles we drive are protected on the outside with space-age polymers in the waxes we use, and engineered on the inside with technologies and products revealed in detail in the New on the Market section. The NASA-sponsored Technology 2000 conferences have benefitted many companies and most important, the transfer of technology among their employees."

Richard K. Kirchner
Computing Devices International
Bloomington, MN, 12-year reader

"My research was focused on the production and characterization of magnetically confined plasmas, and our experiment incorporated many of the generic components of any physics laboratory, from optics to pulsed power to gas handling to vacuum systems. In my monthly issue of *NASA Tech Briefs*, I could count on discovering an innovative solution to a problem analogous to one which I was facing in the laboratory, particularly in the area of mechanical design. Over the past several years, I have repeatedly passed along suggestions to colleagues about novel sensors, computational algorithms, and diagnostic techniques, leaving them ragged, torn articles in their mailboxes with a handwritten scribbled note saying, 'I found this in *NASA Tech Briefs* and it might help you out.'"

Jack Shlachter
Los Alamos National Laboratory
Los Alamos, NM
17-year reader

"For my personal career as a scientific executive and presently as an independent consultant in radiation physics and environmental public health, what has been of more decisive significance than the acknowledged utility of particular devices and technologies has been the knowledge of the broad spectrum of advances made accessible by work in NASA and other national laboratories, as well as private industry. With respect to the latter, one cannot overestimate the value of the superb detailed catalogs and literature available to readers."

"As an early patent holder in the applied optics area, a patent for the laser photocoagulator used in treating ocular disorders and one for generating laser action with nuclear power generators, I find that the *Laser Tech Briefs* supplement is the most compact and informative source for keeping abreast of this specialized accelerating field."

Leonard R. Solon
Consultant, Hopewell Junction, NY
10-year reader

"As senior scientist for Litton Industries/Aero Service Corporation, I was engaged in both air- and space-borne remote sensing. This specialization included assignments as a principal investigator for NASA's SIR-B radar program and responsibility for application of NASA's SST-borne large format camera. My conscience has me hoping that I gave *Tech Briefs* sufficient credit for the numerous times I extracted timely, pertinent articles and data on these two subjects in my dealings with my management, co-workers, and clients."

Allen M. Feder, Ph.D., retired
Mobile, AL, 20-year reader

"The biggest value of *NASA Tech Briefs* is its diversification of topics. It is like having a complete, yet dynamic, design tool box. Typical of this concept is how on a design some 16 years ago, a precision zero slip mechanical ball and disc integrator had to be developed. Conceptual design was not that difficult, but building and then mass producing it presented a few challenges. Almost as if on call, *NASA Tech Briefs* provided materials and mechanics topics that were applicable."

"The design experience was followed later by a new challenge requiring a design and manufacture of an electron beam lithography tool, which was then at the leading edge of micro chip production and a new industry. Cost-effective producibility of an electron beam lithography tool was critical. It was the availability and utilization of some topics identified in *NASA Tech Briefs* that expedited implementation of fabrication of the tool."

Jerome Charles Zajic
PSPI Inc.
Homosassa, FL
20-year reader

Some Excerpts from Your Letters

"What makes NASA Tech Briefs unique is that information is presented in a way which facilitates the transfer of insights from one industry to another. The ability to view problems and opportunities from a range of perspectives and to transfer ideas from one field to another will become increasingly important in the future."

Robert Schechter
New Canaan, CT, 10-year reader

"As a result of reading NASA Tech Briefs, I can truthfully say that technologies and products featured in the magazine have enabled my company to simplify the design and manufacturing of equipment that we make for the motion picture industry."

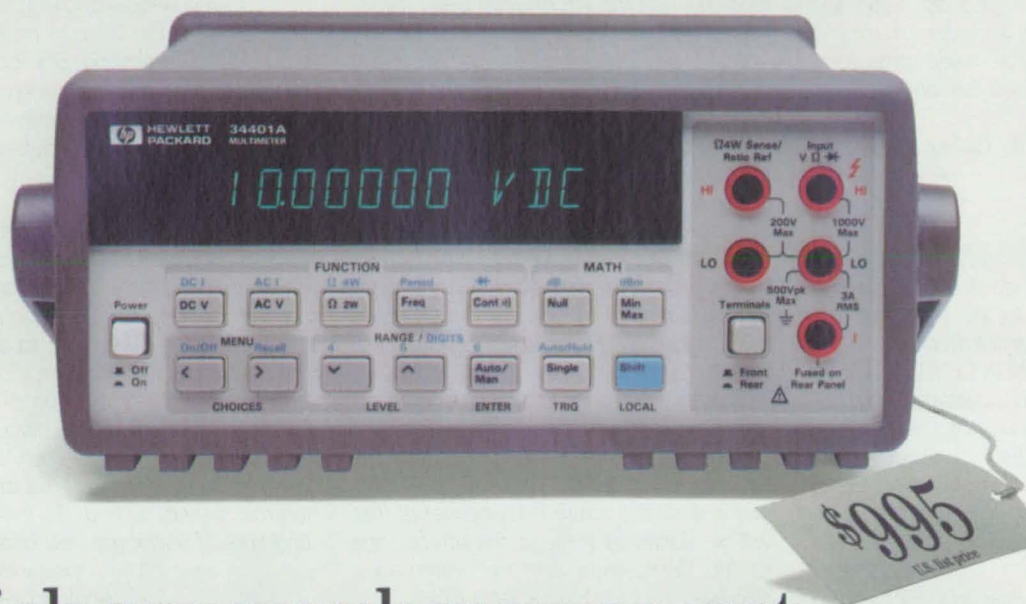
Randall L. Weatherington
Mojave, CA, 5-year reader

"I consider NASA Tech Briefs to be the major link between scientific research at its highest level and the general business sector. NASA Tech Briefs inputs and influences a professionalism required in today's industrial millennium."

Larry R. Lambert
Maremont Exhaust Products
Loudon, TN, 3-year reader

(continued on page 32)

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(continued from page 30)

"I find that understanding airflow in internal conduits is interesting and challenging. I am fortunate enough to work as a technician in the airflow room of a large diesel engine manufacturer. I have used several ideas gleaned from the magazine in my job, including making a smoke generator that uses propylene glycol that was based on an article in Tech Briefs."

Fred L. Cailey, Batavia, IL
4-year reader

"NASA Tech Briefs has provided more than just stimulating ideas over the years. Many a new product or, I should say, products which I was not aware of before I saw their ads in "NASA Tech Briefs have helped solve design problems on projects on which I was working at the time. For example, finding a source for mechanical drive system parts from Stock Drive Products helped solve some system design challenges."

Richard Baack
Baack Precision Electronics
Weatherford, TX, 16-year reader

"I work for a major airframe manufacturer and have been reading "NASA Tech Briefs for over 10 years. During this time, the information contained in the magazine has been instrumental in helping me obtain a patent, with two more pending. Not only has the information been beneficial personally, but it has aided in solving some problems in manufacturing processes, as well as helping our outside subcontractors. The results have always proved to improve quality, reduce weight and manufacturing costs, and eliminate re-work."

"I believe that the one thing to note is the technology transfer that NASA Tech Briefs promotes. This was quite evident at the Technology 2005 conference held in Chicago last year. As a direct result of the conference, with the active displays, I was able to gather information that will prove beneficial to the U.S. Army for a composite repair program tentatively scheduled for this coming year. This is just one of the future developments that will be achieved through the attendance at the conference and the information released through NASA Tech Briefs."

M.A. Williamson, The Boeing Co.
Seattle, WA, 10-year reader

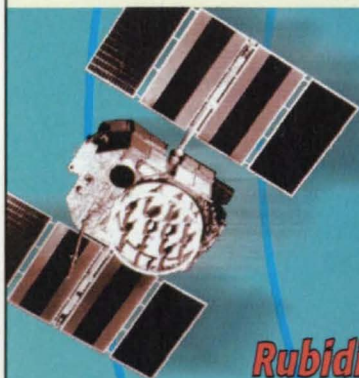
"NASA Tech Briefs provides a window into the future of technology that will impact our nation and the world. Each article contribution is equally important. The magazine is not about the nuts-and-bolts of the specific reports; it is a banner of dedicated people applying science and technology in the hope of making a contribution to improving our country and world society for future generations."

Chris Nawalaniec
Cincinnati, OH, 5-year reader

"The technology and new product innovations featured over the years have creatively inspired some future concepts and product developments. It also has helped me to envision new ways to approach a unique product or problem. For example, a recent article, 'Simulation of a Thermal System,' (August 1996) discussed digital/analog system simulation. After reading this article, it inspired me to simulate a thermal system without the initial expense and time of building a new one."

Vincent A. Miraglia
Analog Design Group
Westwood, NJ, 3-year reader

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Cast Your Vote for



TECH BRIEFS

Second Annual Product of the Year Award

Each issue of *NASA Tech Briefs* highlights the Product of the Month – a new product in each issue with exceptional technical merit and practical value to our readers.

This month, *NASA Tech Briefs* readers are invited to vote for the one product among those highlighted this year that you feel is the most significant new product introduced for the engineering community in 1996. The product with the most votes will be awarded *NASA Tech Briefs*' 1996 Product of the Year.

Last year, *NASA Tech Briefs* readers awarded co-honors to Autodesk's CD-ROM Mechanical Library and SolidWorks 95 solid modeling software from SolidWorks.

Here is your chance to choose this year's winner. On the facing page are descriptions of each of the Products of the Month and the issues in which they appeared. Choose the ONE product you feel should receive Product of the Year honors, and indicate it on the ballot below. Fax or mail this completed ballot by January 15, 1997 for your vote to be counted.

The first 100 voters will receive a free CD-ROM, "NASA Solutions—Sharing Aerospace Technology with America" (\$250 value), featuring searchable databases and computer programs representing the best of NASA technology over the last decade, as well as NASA patents and technical reports.

The Product of the Year will be announced in the March 1997 issue.

1996 NASA TECH BRIEFS PRODUCT OF THE YEAR BALLOT

Indicate your ONE choice for 1996 Product of the Year by marking an 'X' in the appropriate box. Fax or mail your completed ballot by January 15, 1997 to Linda L. Bell, Chief Editor, NASA Tech Briefs, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864.

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Mark an 'X' in the box next to your choice for *NASA Tech Briefs* 1996 Product of the Year.

(CHECK ONLY ONE BOX!)

☐ January: Intergraph Corp. - Solid Edge CAD software for mechanical assembly and modeling.

☐ February: Silicon Graphics - Onyx Infinite Reality visualization supercomputer

☐ March: FieldWorks - FW7600 Field WorkStation rugged laptop computer

April: Withdrawn

☐ May: Interactive Process Controls - SensorPulse generic analog signal processors

☐ June: Nomadics - Modular instruments

☐ July: Fluke Corp. - ScopeMeter B dual-channel test tool

☐ August: Knowledge Revolution - Working Model 3D virtual prototyping & design software

☐ September: Software Partners/32 - SafetyPosit data backup service

☐ October: Computervision - Electronic Product Definition (EPD) software tool suite

☐ November: LeCroy - Digital oscilloscopes

☐ December: Matra Datavision - Euclid Quantum software tools

Product of the Year Nominees

January Product of the Month



Solid Edge™, new CAD software for mechanical assembly and part modeling from Intergraph Corp., Huntsville, AL, was developed specifically for Windows® 95 and Windows NT™ operating systems. It addresses fundamental mechanical design issues involving parts systems, such as part-to-part interface, interference, and assembly configuration. Solid Edge includes object linking and embedding data server software that enables the user to link, view, and locate models created with other CAD systems. It also incorporates Spatial Technology's ACIS® solid-modelling kernel for advanced 3D mechanical design. It is priced at \$5995.

February Product of the Month



Silicon Graphics, Mountain View, CA, has introduced Onyx InfiniteReality™, a visualization supercomputer that simultaneously processes graphics, imaging, and video data in real time. Delivering more than 10 million polygons per second, the system provides 5 GFLOPS for image processing and downloads 200 MB of data per second into a visualization pipeline. The system enables creation of virtual 3D characters, 3D imaging, and volume rendering, and incorporates geospecific texturing for realism in visual simulation and high-end CAD applications. The computer supports from two to 24 MIPS® R4400™ processors and 64 MB to 16 GB of memory.

March Product of the Month



FieldWorks, Eden Prairie, MN, has introduced the FW7600 Field WorkStation™ rugged laptop computer, which features 100 MHz 486 or Pentium processors. The computer operates on AC, battery, or 12V DC input power and includes multiple slots: one PCMCIA slot and three ISA slots for the standard model; one PCMCIA plus three ISA or three PCI slots (or any combination of the two) for the Pentium model. It weighs 14.7 pounds, and features a sealed Field MousePad pointing/drawing device, integral CD-ROM drive, and a one-piece chassis that meets military standards for shock and vibration.

May Product of the Month



Interactive Process Controls Corp., South Easton, MA, has introduced a new family of SensorPulse™ generic analog signal processors, which replace analog input and output modules in programmable logic controllers (PLCs) by converting analog signals to 12- or 16-bit data, and communicating the data to a PLC via a single digital I/O point. Any type of sensor can be used for machine and processor control with any PLC, PC or standalone application. SensorPulse's Intel-based processor works with thermocouples, strain gauges, potentiometers, frequency, current, and voltage over a wide analog range. Also included are signal conditioning and communications algorithms and preloaded software drivers for all major PLCs.

June Product of the Month



Nomadics, Stillwater, OK, offers modular instruments, which use desktop, laptop, and handheld computers in conjunction with credit-card-sized plug-ins, allowing engineers to carry lightweight instruments or free up bench space. The instruments work with any computer equipped with a PCMCIA slot, and consist of a sensor interfaced to the PCMCIA card. Data does not need to be transferred to a computer for processing, display, or storage; it can be viewed in multiple real-time formats. Instrument functions can be integrated with other resident capabilities, such as communication via modem. Available instrument cards include a basic pH card kit; a pH logging system; a conductivity meter; a thermocouple data logger; and a six-channel thermistor datalogger card.

July Product of the Month



Fluke Corporation, Everett, WA, has introduced the handheld ScopeMeter™ B 100 MHz dual-channel test tool, which features a cold-cathode, fluorescent backlit display that is ten times brighter than previous ScopeMeter displays. It incorporates a 5 MHz true-rms digital multimeter that allows users to view waveforms and meter readings simultaneously. The unit features a 30k memory in ScopeRecord™ mode, allowing it to record and show events as long as 125 scope screens. The tool comes with a rechargeable NiCad battery pack, power adapter/battery charger, two 600V probes, test leads, probe set, and accessory case. Selected models include FlukeView software, serial interface cables, and a built-in signal generator.

August Product of the Month



Knowledge Revolution, San Mateo, CA, has introduced the 3D version of Working Model® virtual prototyping and design software for development and motion simulation of mechanical systems in Windows environments. Working Model 3D™ features a point-and-click user interface, CAD integration, rapid simulation, and extends desktop engineering to both planar and spatial elements. Models can be created graphically, without specifying values or equations. The program integrates modeling, simulation, and analysis and offers an array of 3D joints and constraints such as motors, actuators, rods, and springs. An automatic collision detection feature in which solids interact, slide, and collide is provided, allowing users to model boxes moving over rollers or conveyors.

September Product of the Month



Software Partners/32, Topsfield, MA, has introduced SafetyPosit, a software-based data backup service that backs up irreplaceable data to a secure, remote storage site over an Internet connection. The storage vault can support up to 9 terabytes of data and includes a security firewall, a RAID server to receive backups, and a robotic tape library for storage. A 128-bit data encryption system encrypts data before leaving the desktop, and it is stored in encrypted format. Only the user with the original key can read the data. Pricing ranges from \$49.95 per month for 100 MB of data to \$395 per month for up to 1 gigabyte of monthly new data.

October Product of the Month



Computervision, Bedford, MA, offers Electronic Product Definition software tool suite that enables the specification, concept, design, analysis, drafting, manufacturing, and support of a complete product to occur simultaneously, and allows the product to be shared electronically. A digital model is created, displayed on screen, and made available anywhere in an enterprise for developing, testing, and managing the product through its life cycle. Each participant interacts with the model without interfering with what others are doing. Included in the suite are CADD5® 5 design automation software, Concurrent Assembly Mock-Up (CAMU), Optegra™ enterprise data management software, and PELORUS™-based design automation software.

November Product of the Month



LeCroy, Chestnut Ridge, NY, has introduced the LC334 and LC534 digital storage oscilloscopes, which feature 9" color CRT displays that allow signals to be viewed using the entire screen, 96 MHz Motorola PowerPC™ microprocessors, 64 Mb of RAM, and 2 Mb of data acquisition memory per channel that can be combined to 8 Mb on a single signal. The four-channel scopes offer acquisition memory up to 2 million points per channel and feature 500 MS/s sampling on each channel. The scopes include diagnostic, troubleshooting, and documentation tools such as measurement of over 40 signal parameters, worst-case analysis, and an enhanced math package. PCMCIA III capability is optional.

December Product of the Month



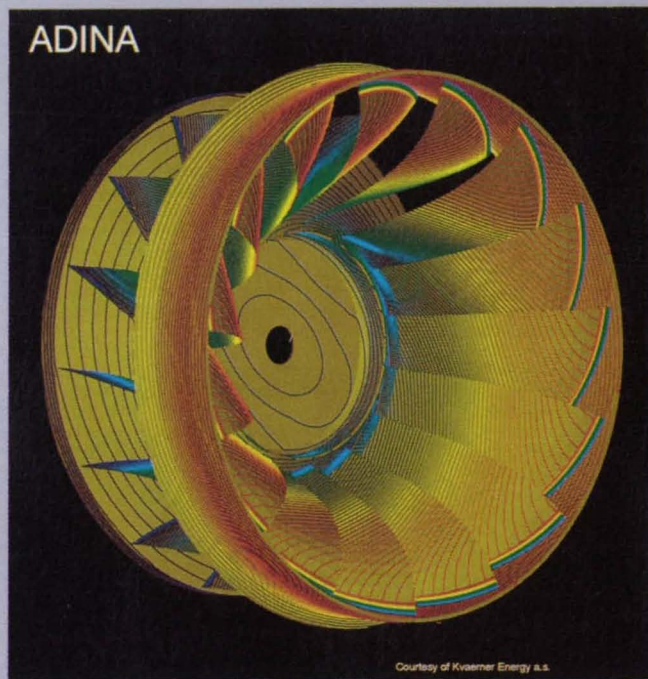
Matra Datavision, Andover, MA, has introduced Euclid Quantum CAD/CAM/CAE and PDM software suite based on an object-oriented architecture. The suite includes Euclid Designer 3D modeling software for designers in concurrent engineering environments; Euclid Analyst, a what-if analysis environment for simulation and model preparation; Euclid Machinist, for creating the best machining tool path for a part model; and Euclid Design Manager, which integrates and processes engineering data at all stages of the process cycle. The four environments are linked through Euclid Desktop, which accesses external applications and provides for data exchange. Package pricing begins at \$9,900.

April
Product of the Month
Withdrawn

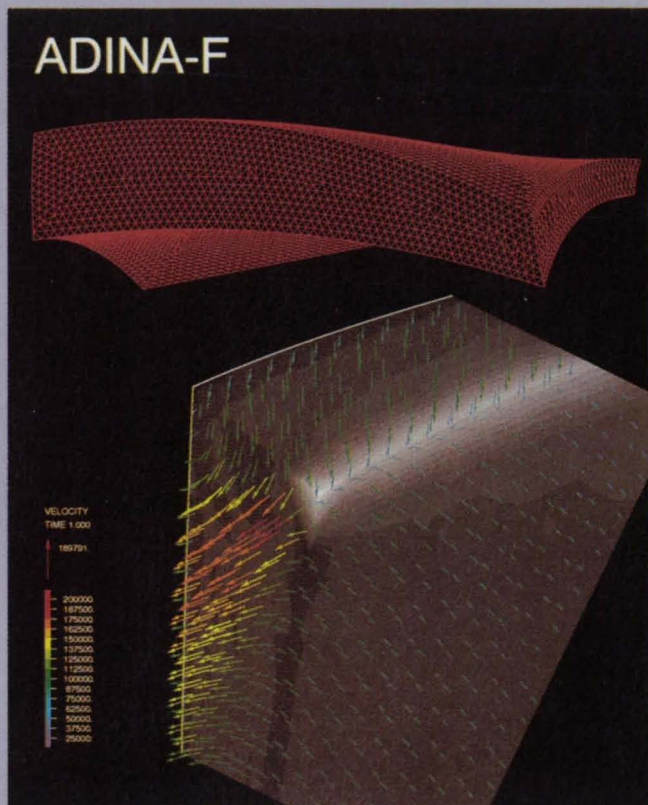
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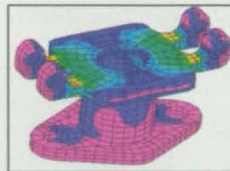
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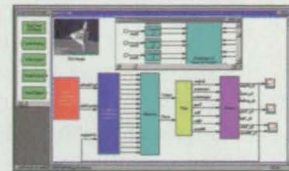
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**Modeling/synthesis software
enables robust control system
design**

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**Compressor design software
can reduce development costs**

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**Program predicts pump
performance for analysis and
conceptual design**

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**Software provides 2D/3D
interactive video displays of
data and text**

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**Software uses cause-and-effect
analysis to define and solve
engineering problems**

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**Visualization software program
uses CAD files to view
3D designs**

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**Mathematical systems analysis
provided by Windows software**

page 48

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Software for Mathematical Modeling of Dynamics and Controls

This software enables synthesis of robust multivariable control systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Modeling and Control Synthesis Toolbox (MACSYN) computer program is an integrated package of software for automated mathematical modeling, identification, and robust control design. MACSYN contains software modules for system identification (identification and estimation of parameters of mathematical models of the dynamics of systems) and for representation of the bounds on uncertainty in the mathematical models, in forms directly useful in designing robust control subsystems. Plants are represented in state-space form, while uncertainties in mathematical models are characterized in terms of weighting functions, the norms of which are bounded. MACSYN is written as programmable M-files in the MATLAB computing language. Going beyond simulation and analysis, MACSYN can process raw experimental data to design a robust multivariable digital control subsystem that would provide an optimal combination of stability and control performance in the presence of disturbances, noise, and uncertainties in the mathematical model of the plant.

MACSYN is applicable to a plant characterized by multiple linear dynamical equations with time-invariant parameters; the parameters can be initially unknown and can later remain uncertain to a degree, as described below. In a representative application, the plant could be a complex flexible structure like a large radio antenna equipped with rotary aiming actuators and/or translational vibration actuators and sensors. One might use MACSYN to design a control system that would provide the required aiming performance while suppressing vibrations.

The figure shows the major functional blocks of a system as modeled mathematically in MACSYN. The dynamics of the plant can be characterized experimentally by measuring its output, y , while exciting it with a known multisinusoidal input excitation, u_s . P denotes the true (and at least partly unknown) plant, while \hat{P} denotes the estimate of the plant (more precisely, the state-space representation of the plant with parameters estimated by

MACSYN or by any other means). Δ_A denotes the additive uncertainty in the estimate; that is, $\Delta_A = P - \hat{P}$. C denotes the digital control subsystem. W_d denotes a frequency-weighting filter that characterizes the effect of a disturbance, d , on the plant output, y .

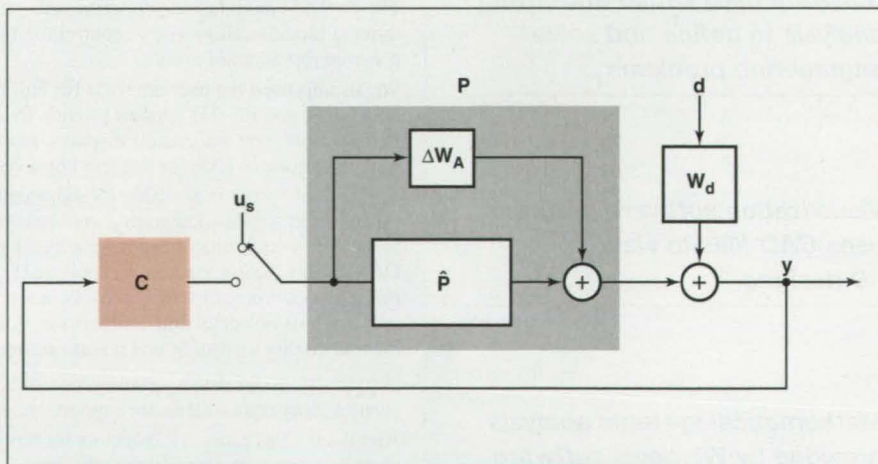
For the purpose of designing the digital control subsystem, it is desirable to introduce an additional weighting filter, W_A , and to represent the additive uncertainty in the form $\Delta_A = \Delta W_A$ where Δ is a norm-bounded perturbation, specifically, such that $\|\Delta\|_\infty \leq 1$ and where $\|\cdot\|$ denotes the infinity norm of a mathematical operator. Then, typically, W_A is incorporated into the control design to ensure robustness properties over the additive uncertainty set. MACSYN computes P and W_A such that, to a statistical confidence $1-\kappa$ specified by the designer, $P = \hat{P} + \Delta W_A$ for some $\|\Delta\|_\infty \leq 1$. In the case of a plant estimated from measurement data, the additive uncertainty set is called the "empirical plant set" and constitutes the set of plants that cannot be discounted on the basis of those data. Methods for the synthesis of robust control systems then can be used to find a design for C such that it yields the desired stability and performance for plants in the uncertainty set defined by P and W_A .

In MACSYN, an automated software framework simplifies the modeling and

control-design procedure and enables the design of robust, high-performance feedback controls for plants that would otherwise be difficult to characterize and control reliably. Robust controllers designed with respect to empirical plant sets tend to be more reliable than are those designed with respect to less systematic or ad hoc specifications of the uncertainty set.

Because MACSYN is based partly on the assumption that the plant is linear and time-invariant, some uncertainties and modeling errors may not be represented in the empirical plant set in a case in which the plant behaves nonlinearly and/or with time-varying parameters. In such a case, the designer may wish to add extra uncertainty blocks to increase the robustness in the final control design. Like any other design aid, MACSYN should be used with engineering judgment and is flexible enough to be usable in combination with other aids to obtain the best final control design.

This work was done by Asif Ahmed, David S. Bayard, Richard Y. Chiang, Edward Mettler, and Robert E. Scheidt of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 58 on the TSP Request Card. NPO-19408



This Graph Represents the Relationships among subsystems and components within an overall system as modeled mathematically in MACSYN for the purpose of designing a robust controller, C .



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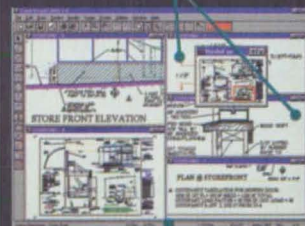
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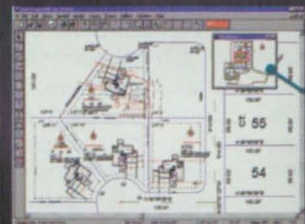
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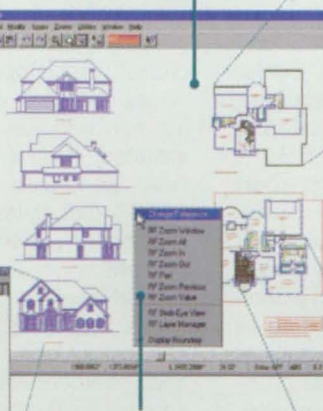
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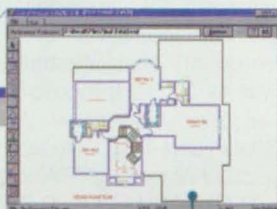
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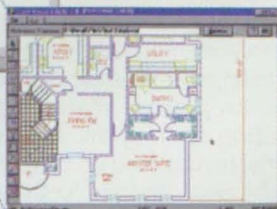
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Software for Integration of Multidisciplinary Design Efforts

NASA's Jet Propulsion Laboratory, Pasadena, California

The Multidisciplinary Integrated Design Assistant for Spacecraft (MIDAS) computer program is undergoing development to satisfy a need for software that would aid multidisciplinary design efforts in a way that no other single piece of software does. When fully developed, MIDAS would reduce life-cycle costs by promoting the reuse of previously acquired design information and the sharing of design information among design-team members who work in different engineering disciplines and/or use different application programs. MIDAS provides an inter-software-communication capability for capturing design solutions from different application programs, thereby providing a common vis-

ibility for those solutions; it also manages communication, coordination, and cooperation among design-team members. MIDAS provides an intuitive, graphical-object-based execution environment, enables control and execution of computer codes independent of computer hardware and operating systems, accommodates the use of other software already in use, and is relatively inexpensive. MIDAS has been tested on UNIX workstations and on Macintosh-compatible computers, and is planned for IBM PC-compatible computers.

This work was done by John C. Peterson, Julia R. George, and Samuel N. Southard of Caltech for NASA's Jet Propulsion Laboratory. For further

information, write in 25 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

*Larry Gilbert, Director
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California Institute of Technology
Mail Code 315 - 6
Pasadena, CA 91125
(818) 395-3288*

Refer to NPO-19649, volume and number of this NASA Tech Briefs issue, and the page number.

Program for Multidisciplinary Finite-Element Analysis

Dryden Flight Research Center, Edwards, California

STARS is a highly graphics-oriented computer program for multidisciplinary, finite-element-based, linear and nonlinear analysis. Its range of application includes structural analysis, heat transfer, linear aerodynamics, computational fluid dynamics (CFD), and controls engineering. It provides extensive graphics capabilities for convenient development of mathematical models as well as for postprocessing of analysis results. Examples of advanced NASA-Dryden Flight Research Center projects analyzed by STARS include X-29A, F-18 HARV/TVCS, B-52/Pegasus, Generic Hypersonics, NASP, SR-71, and the high-speed civil transport (HSCT), among others.

STARS is composed of modules that are fully integrated to yield unique multidisciplinary modeling and simulation capabilities. The SOLIDS module is capable of analyzing static, stability, vibration, and dynamic-response problems for a wide variety of structures, including spinning structures subjected to mechanical and/or thermal loading. It can also perform both linear and nonlinear analyses. An extensive element library contains information on one-, two-, and three-dimensional elements, including composite-material and sandwich elements, with general material properties. Structural as well as viscous damping can be included in analyses.

The SOLIDS HEAT TRANSFER module provides STARS with its capabilities for analysis of thermal conduction. Both steady-state and transient conditions can be analyzed, and nonlinear effects can be included. The element library of this module contains information on line, shell, and solid elements (including composites).

The AEROELASTIC and AEROSERVOELASTIC modules are capable of predicting the stability characteristics of aircraft and spacecraft structures. These modules can be used in conjunction with the SOLIDS module. For instance, once a vibration analysis has been performed by use of SOLIDS, STARS can determine the flutter and divergence characteristics and can perform open- and closed-loop stability analyses.

The CFDASE module provides a capability for nonlinear aeroelastic and aeroservoelastic analysis. It enables effective computation of unsteady aerodynamic forces by use of both finite-element-based structural and CFD techniques. The associated PROPULSION module employs CFD techniques for simulation of flow-mixing phenomena.

A preprocessor submodule enables the automated generation of nodal, element, and other associated input data for any continuum. It is capable of generating complex structural forms

through duplication, mirror-imaging, and cross-sectioning of modular representative structures. This submodule also includes a capability for fully automated generation of three-dimensional meshes. Two postprocessor submodules provide extensive color plotting of various structural, heat-transfer and CFD-related results.

STARS includes utility software for translating NASTRAN and MSC/NASTRAN input data for structures into STARS input data. NSTARS transforms the Bulk Data portion of the NASTRAN input file. Specifically, it can translate defining coordinate systems, grid points, grid-point constraints, rod elements, bar elements, triangular and quadrilateral shell elements, composite shell elements, tetrahedral and hexahedral solid elements, material properties, and distributed mass loads.

STARS is written in FORTRAN 77 for IBM RS/6000 workstations running AIX 3.2.x or 4.x and is available as executable code only. STARS has been successfully implemented on an IBM RS/6000 590 computer running AIX 3.2.5 and an RS/6000 550 computer running AIX 4.1.4. The graphics-based postprocessor submodules require both an IBM three-dimensional GT graphics adapter and IBM's graPHIGS library. STARS requires approximately 6 MB of disk space for installation of program executable codes; the disk



A MATLAB plot of a lookup table provides visualization of a correction surface for manifold pressure as a function of engine speed.

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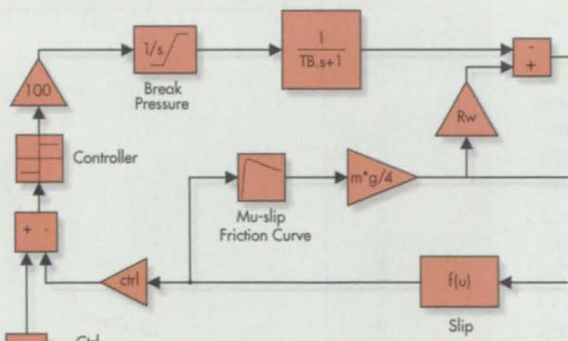
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At Chrysler, engineers use MATLAB for development of advanced powertrains. Photo of Dodge Viper RT10 Roadster, courtesy of Chrysler Corporation.

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For More Information Write In No. 645

spaces needed to accommodate input and output data for extensive test problems are about 3 and 12 MB, respectively. The standard distribution medium for STARS is one 0.25-in. (6.35-mm)

streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. STARS was released in 1996.

This program was written by K. K. Gupta of Dryden Flight Research Center. For further information, write in 78 on the TSP Request Card. DRC-95-37



Software for Optimizing a Multistage Axial Compressor

This software can accelerate the design cycle and reduce the cost of development.

Lewis Research Center, Cleveland, Ohio

An integrated computer code for optimizing the design of a multistage axial compressor incorporates two preexisting codes — (1) UDO300M, which mathematically models axisymmetric flow by use of a streamline-curvature procedure; and (2) Automated Design Synthesis (ADS), which is a general-purpose optimization program. In a typical case, the integrated code takes less than 2 hours of central-processing-unit time to arrive at a design that is optimum in the sense that it maximizes the overall isentropic efficiency of the compressor. Thus, the integrated code can reduce both the design-cycle time and the cost of development.

In the integrated code, pressures and solidities on the trailing edges of rotor blades and flow angles and solidities on the trailing edges of stator blades are considered as design variables. The design problem is posed as a constrained optimization problem by limiting (1) diffusion factors at all radial stations in a row of blades and (2) the surge-margin-capacity parameter of each stage. These limits are established on the basis of the experience of compressor-design engineers. Only a few control points along the trailing edge of each blade are chosen as design-variable stations, and the values of the design variables at other radial stations are obtained through cubic-spline interpolation.

UDO300M solves the momentum and continuity equations in the meridional plane, determining the streamline distribution that satisfies these equations plus specified constraints. In the streamline-curvature procedure, a computational mesh is formed by the intersection of the defined computational stations with the computed streamlines, the locations of which are determined iteratively. Initially, streamline locations are estimated. On the basis of this estimate, the flow within the compressor is computed. The estimates of the streamline locations are then revised by use of the computed flow. This procedure is repeated until the streamline pattern is correct to within a tolerance specified by the user.

UDO300M fundamentally consists of two sections — a blade-geometry-definition section and an aerodynamics section. The aerodynamics section can be run in either an analysis or a design mode. In the design mode, the user specifies the radial distributions of total pressure, total enthalpy, absolute angular momentum, or absolute whirl velocity at each computing station common to the blades in each row. In the analysis mode, the relative-flow-angle distribution at each station is specified either directly or via specification of the blade-angle and deviation-angle distributions. Losses for each blade row can be specified and held constant or recalculated and updated as the computation proceeds.

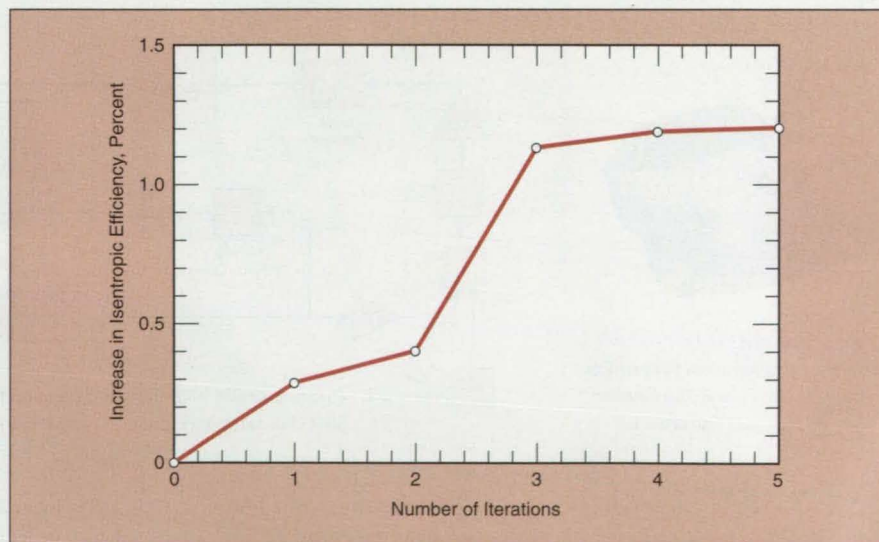
A design pass consists of one aerodynamical analysis plus at least one computation to define blade geometries. A single computer run can include multiple design passes, in which case multiple aerodynamical analyses are performed. Multiple blade-definition computations are performed if more than one blade row is being designed or if a single blade row is being designed with multiple design passes.

Optimization of design is effected by

an algorithm that implements a modified version of the method of feasible directions, handles the constraints directly, and performs polynomial interpolation. The optimization procedure includes a computation of gradients by a finite-difference technique that is implemented in ADS. The optimization procedure is initiated via interface software in the form of a Unix shell script that is written for one function evaluation and is rerun automatically until values computed on successive iterations converge. Each function evaluation consists mainly of generating the UDO300M input, calling the optimization algorithm, and postprocessing the UDO300M output.

The integrated code has been demonstrated by applying it to the design of a four-stage compressor with one guide vane, four rotors, and four stators. The results of the computation showed that the isentropic efficiency could be increased by 1.2 percent relative to a baseline value (see figure).

This work was done by D. R. Reddy of Lewis Research Center and E. S. Reddy of NYMA, Inc. For further information, write in 6 on the TSP Request Card. LEW-16288

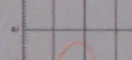


Only Five Iterations were needed to converge on a modified, optimum design for a four-stage compressor with an isentropic efficiency 1.2 percent greater than that of the baseline design.

EMSS is a technology breakthrough in the design and analysis of electromechanical systems. This leap in technology combines finite element analysis (FEA), mechanical dynamics and electronic circuit equations in a comprehensive, easy-to-use software package for electrical and mechanical engineers.

Force vs. Stroke

The graph shows a red line with circular markers on a grid. The line starts at a high point on the y-axis and slopes downward as it moves to the right, indicating a negative correlation between the two variables.

[illegible]

A graph showing the coil current over time. The y-axis is labeled 'Coil Current' and ranges from 0 to 0.04. The x-axis is labeled 'Time' and ranges from 0 to 0.04. The current starts at 0, rises to a peak of approximately 0.035 at 0.015s, drops to a minimum of approximately 0.01 at 0.025s, and then rises again to a steady state of approximately 0.038 at 0.04s.



Program Estimates Lifetimes and Reliabilities of Gear Trains

Lewis Research Center, Cleveland, Ohio

TLIFE is a computer program that estimates the lifetimes, dynamic capacities, and reliabilities of aircraft transmissions, enabling optimization of transmissions at the design stage of development. Optimization at this stage offers the promise of improved capabilities and service lives with affordable development costs. Transmissions that are lighter, smaller, and longer-lasting than present transmissions will improve overall aircraft performances.

The reliability and life analyses performed by TLIFE are based on the two-parameter Weibull-distribution lives of the component gears and bearings. Either the SI metric or the English system of units can be used. A variety of transmissions can be analyzed; these include spur, helical, and spiral bevel reductions and series combinations of these reductions. The basic spur and helical reductions include single-mesh,

compound, and parallel-path plus reverted star and planetary gear trains. A variety of straddle and overhung bearing configurations on the gear shafts are possible, as is the use of a ring gear for output. The spiral bevel reductions include single- and dual-input drives with arbitrary shaft angles.

The program output describes an overall transmission and each constituent transmission, its components, and their locations, capacities, and loads. Primary output includes the dynamic capacity and the 90-percent-reliability and mean lives of the unit transmissions and the overall transmission.

TLIFE is written in FORTRAN 77 to be machine-independent. It has been successfully implemented on the following computers: a DECpc 486DX/33 running DOS 5.0, a SUN Sparc workstation running SunOS 4.1.3, a SUN Sparc workstation running Solaris 2.4, an HP

9000/700 running HP-UX 9.03, a 486DX/66 running Linux 1.3.40, a DEC Alpha running OSF/1 v2.0, an SGI Indigo 2 running IRIX 5.2, a Cray Y-MP running UNICOS 8.0.3.4 and a MicroVAX running VMS 5.5_1. The standard distribution medium for TLIFE is one 3.5-in. (8.89-cm), 1.44MB diskette in MS-DOS format. The contents of the diskettes have been compressed by use of the PKWARE archiving software tools. The utility software to unarchive the files, PKUNZIP.EXE v2.04g, is included. Alternate distribution media and formats are available upon request. TLIFE was released in 1996.

This program was written by M. Savage, K. L. Rubadeux, and M. G. Prasanna of the University of Akron for Lewis Research Center. For further information, write in 91 on the TSP Request Card.
LEW-16291

Program Estimates Flows in Centrifugal and Axial Pumps

Lewis Research Center, Cleveland, Ohio

The PUMPA computer program implements a meanline flow method for rapid mathematical modeling of cryogenic rocket-engine pumps. The program predicts the performance of a pump at off-design operating conditions, given the loss of the diffusion system of the pump at the design point. The design-point rotor efficiency and slip factor are obtained from empirical correlations to rotor-specific speed and geometry.

PUMPA can model axial, inducer, mixed-flow, and centrifugal pumps, and can model multistage pumps in series. PUMPA is an effective software tool for analysis and conceptual design, featuring short input setup and computer run times and map-generation capabilities that provide information needed for an interface with a rocket-engine-system-modeling code. The capabilities for modeling off-design performances and multistage pumps enable parametric exploration of design space of candidate pump configurations and provide head and flow maps for evaluations of engine systems.

PUMPA is based on the Euler equation coupled with empirical correlations for rotor efficiency. The code provides an

estimate of flow incidences, losses, and inception of cavitation at off-design operating conditions. By use of correction factors, both the rotor efficiency and the slip factor can be modified to match test data. For a given set of pump inlet pressure and temperature, PUMPA can generate a performance-characteristic map. The fluids that can be used in PUMPA models are liquid hydrogen, liquid oxygen, liquid nitrogen, JP-4, water, and air. The properties of fluids are obtained from the GASPLUS program. A version of GASPLUS that is designed to work with PUMPA is included in the PUMPA package.

PUMPA output consists of flow conditions at (1) the leading and trailing edges of the rotor; and (2) the inlet, throat, and outlet of the diffusion system. In addition to the meanline flow conditions at the root-mean-square radius of the rotor, conditions at the hub and tip locations are also calculated. The output describes the flow conditions in terms of velocities, flow angles, pressures, and temperatures. Velocities and flow angles are calculated in both the relative and the absolute frames of reference. Static and

total pressures and temperatures are calculated at the discharge of the rotor and stage. The total head rise, horsepower, and efficiency are summarized for each stage and for the overall pump. The calculation of all performance parameters is repeated at every point of an array of off-design conditions.

PUMPA is written in FORTRAN 77 for IBM PC-series and compatible computers running MS-DOS. The standard distribution medium for PUMPA is a set of two 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskettes. PUMPA was developed in 1994 and released to COSMIC in 1995.

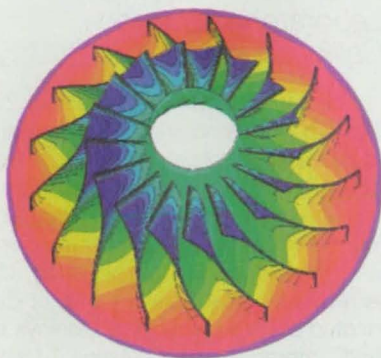
This program was written by Joseph P. Veres of Lewis Research Center. For further information, write in 85 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16173.

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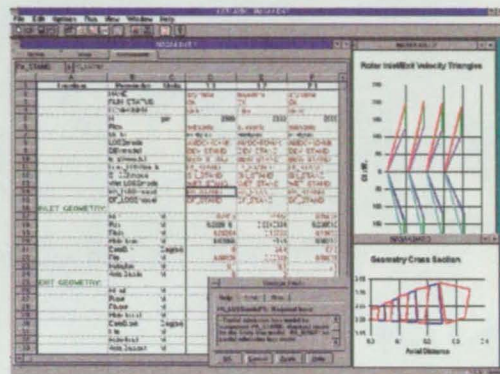
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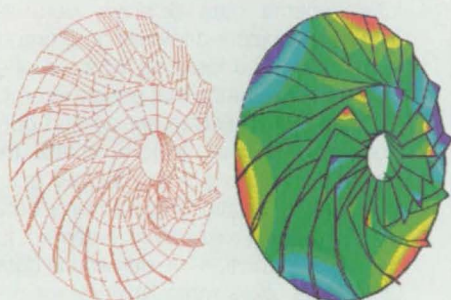


Unsteady CFD - Virtual Laboratory

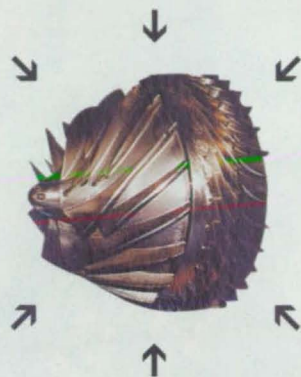
Test Data Reduction & Program Validation in a Physical Laboratory



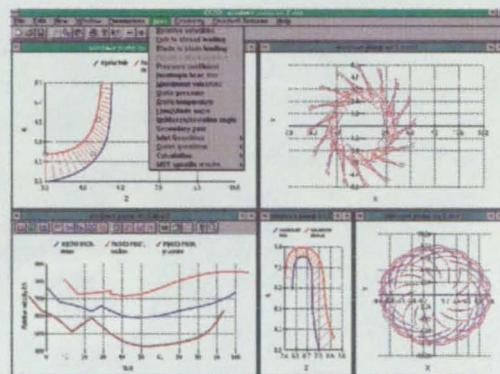
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For additional information please see page 12H in the "Computer Hardware/Software" section of the "Hot Technology File."

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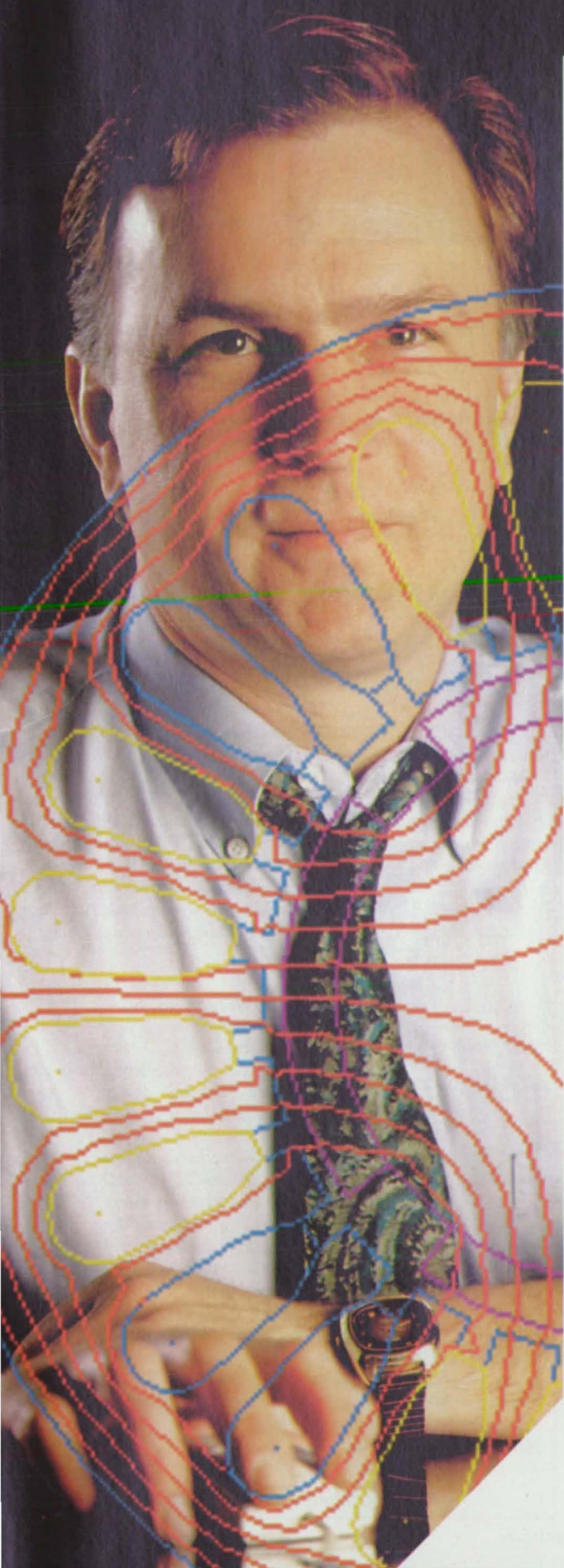
LinkWinds — Flexible Software for Highly Interactive Visual Data Analysis

*NASA's Jet Propulsion
Laboratory, Pasadena,
California*

The Link Windows Interactive Data System (LinkWinds) computer program is an evolving software system for interactive graphical depiction of large, multivariate sets of numerical data. Link Windows provides two-dimensional and three-dimensional-appearing interactive video graphical displays of data, printed copies of graphical displays and text, interactive manipulation of color, interactive creation and display of animation, assignment of data to subsets at input or output, a journal and macro capability, context-sensitive help, and network support for collaborative analysis of data. 'Data-linking' by the user interconnects data displays, controls, and other objects depicted on a graphical display. The resulting links are one-way message paths that enable interobject communication to set up and control structures that, in turn, enable the objects to act in concert for the quick detection of relationships among data. In comparison with other software for graphical depiction of numerical data, LinkWinds offers more flexibility for displaying data in ways that make trends, correlations, and anomalies more recognizable and/or highlighting relationships among data from different sets. LinkWinds is developed under the OpenGL graphics library and is therefore now optimized for Silicon Graphics, Inc., workstations, although it also executes on a variety of other workstations including Sun and Linux. It occupies about 6 MB of disk memory and about 5 MB in random-access memory (RAM), plus whatever additional RAM or swap space may be needed for the user's data files. It is preferable, though not essential, that the workstation and monitor be equipped for double buffering and 24-bit color.

*This work was done by Allan S. Jacobson of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 8 on the TSP Request Card.
NPO-19786*

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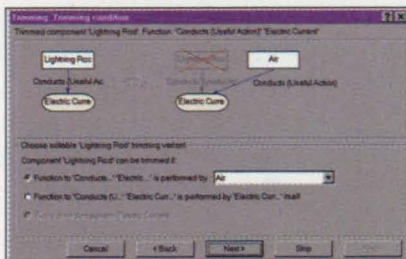
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For More Information Write In No. 607



Design & Analysis Software

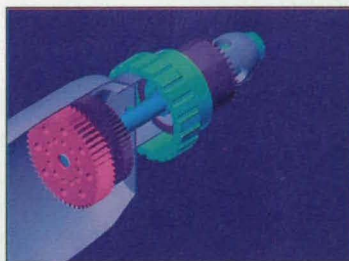


Invention Machine Corp., Cambridge, MA, has introduced Tech Optimizer™ **problem identification and analysis software**, which facilitates the construction of a problem or product statement, helping engineers identify the root

problem. The program is coupled with the company's Invention Machine™ Lab™ 2.11 to provide benchmarking, functional analysis, feature transfer, trimming techniques, and problem management capabilities.

The software uses cause and effect analysis to define and solve engineering problems. Tech Optimizer is available on a Windows 3.1 disk set and is compatible with Windows 95, Windows NT, and on CD-ROM. It runs on IBM-compatible computers and requires 50 MB of hard disk space and 8 MB of RAM. The software is priced at \$1,995 per seat.

For More Information Write In No. 751

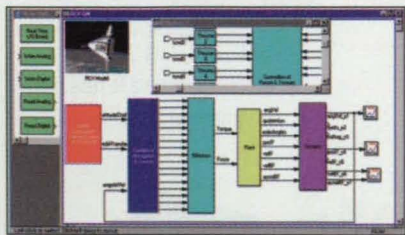


SolidView 2.0 **3D design visualization software** from Solid Concepts, Valencia, CA, uses stereolithography (STL) files generated from CAD systems to view 3D designs on a Windows PC. Users can take an existing CAD design, add measurements and notes, and publish the file to anyone with a Windows-

based PC. Files also can be published over the Internet, a private Intranet, or over digital communications media such as floppy disks.

Other features include network licensing, shading, customizable colors, red-lining capability, and annotation enhancements. The program also reads DXF and OBJ files. It is compatible with Windows 3.1, Windows 95, and Windows NT and sells for \$495. Optional IGES input costs \$495. Options include the ability to prepare STL files for rapid prototyping and to automatically create support structures for rapid prototyping.

For More Information Write In No. 745

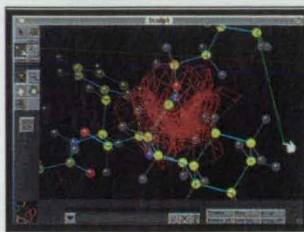


MGA Software, Concord, MA, has introduced ACSL Code, a **code-generation software** which automatically generates C-code from simulation models created by ACSL Graphic Modeler. Engineers can design and simulate a sys-

tem and have C code automatically generated for the system's controller, eliminating manual coding.

The program provides features for creating the model, designing and running experiments, visualizing results, and re-engineering the model. Changes in design parameters can be accommodated with updated code. Applications include developing code for embedded controllers, creating code segments for distributed interactive simulations, hardware-in-the-loop (HIL) testing, and as a standard interface for other simulation products.

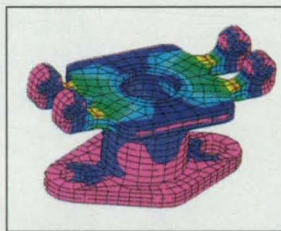
For More Information Write In No. 740



Interactive Simulations, San Diego, CA, has announced the PC version of Sculpt™ **molecular modeling software**, which lets users interactively twist, tug, tether, and overlay molecules in real time on desktop computers. Available on Pentium platforms running Windows 95 or NT, the program enables molecular

mechanics to run in real time. Sculpt can copy and paste to and from CambridgeSoft ChemOffice and Microsoft Office, or output color or black-and-white Postscript images. Images pasted back into Sculpt reappear as the original 3D molecules, allowing data to be stored in external documents and databases. Other features include the ability to superimpose flexible molecules, discovery of conformational similarities, and the ability to build protein models and move secondary structures. Versions are available for PowerMac and Silicon Graphics workstations; the PC version is priced at \$1,195.

For More Information Write In No. 741

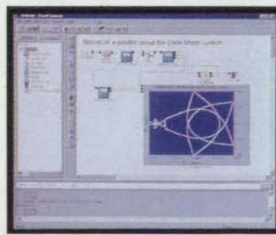


The MacNeal-Schwendler Corp., Los Angeles, CA, has released Version 2.1 of MSC/NASTRAN **modeling software** for Windows 95 and NT. New features include the ability for the ACIS-compatible CAD integration module to accept parasolids-based solid models. Users can take models directly from EDS/Unigraphics and SolidWorks CAD

programs to MSC/NASTRAN for analysis. The software also features a new optional solver called Basic A+.

A nonlinear analysis option supports geometric and material nonlinearity, hyperelastic materials, contact, and creep for static and dynamic analysis. A dynamics analysis option supports transient and frequency response analysis, including random response. A heat transfer module permits simulations which consider steady state and nonlinear transient heat transfer, including a new forced convection technique. A CFD module has a range of capabilities across all flow regimes and speeds. Prices start at \$5,000.

For More Information Write In No. 742



acroScience Corp., Boulder, CO, has introduced Visual Science 1.0 **mathematical systems design software**, which enables users to interactively design, simulate, analyze, and apply complex mathematical systems visually in Windows 3.1, Windows 95, or Windows NT. Users can create a visual model of a mathematical system, highlight the hierarchical structure of a system, analyze the system with interactive tools, scale from simple problems to complex dynamic systems, simulate parallel execution, and manage large projects.

Features include seamless support for MATLAB and IDL; MathCalc, a matrix/array calculation language; more than 100 64-bit real and complex math functions; numerical and graphical data inspectors; and a built-in project explorer. The program also includes support for multi-processor hardware on Windows NT, OLE-based publication and annotation capabilities, a hierarchical block diagram interface, and a traditional command prompt interface. The software is priced at \$895.

For More Information Write In No. 743

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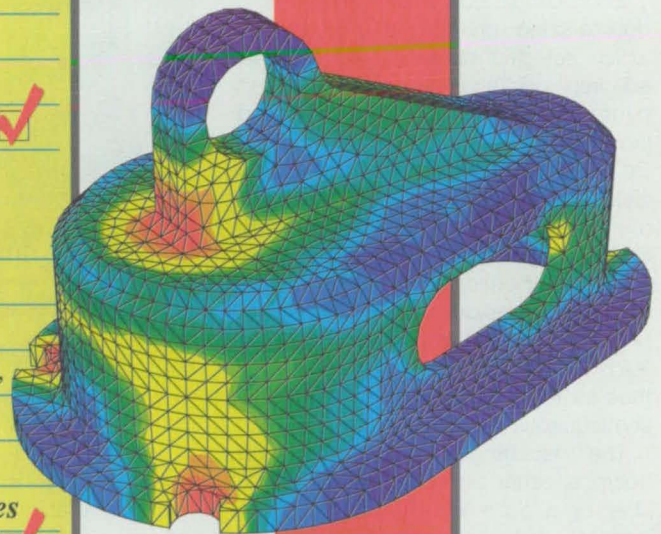
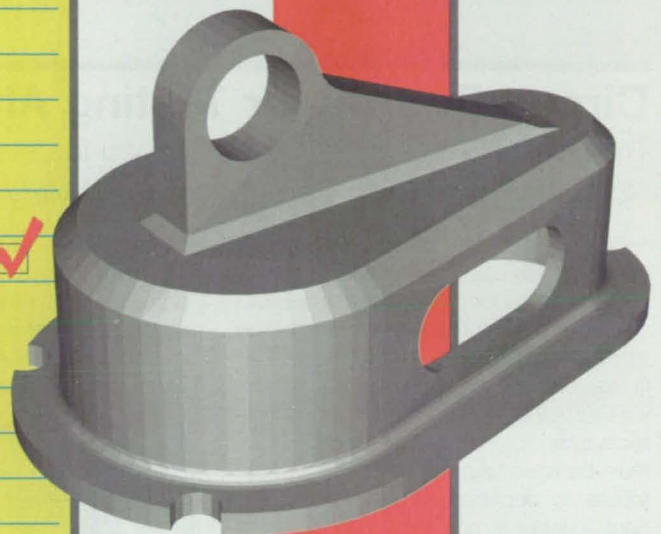
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For More Information Write In No. 647



Electronic Components and Circuits

Circuit Boards for Testing Alternative Cleaning Processes

The boards are cleaned, then examined to determine the effects of cleaning.

Goddard Space Flight Center, Greenbelt, Maryland

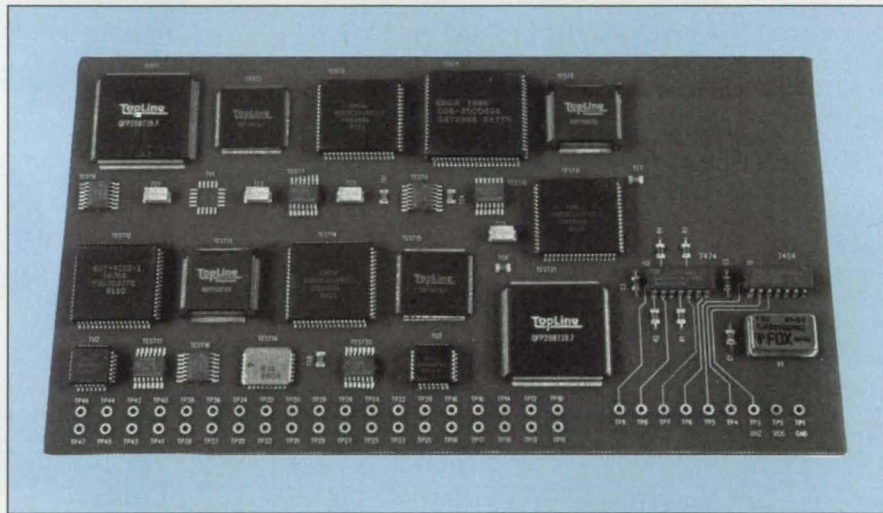
Electronic circuit boards have been designed for use in evaluating innovative processes for cleaning electronic circuit boards during manufacturing. The innovative processes involve the use of fluids other than chlorofluorocarbons (CFCs). Although CFCs have proven effective in cleaning circuit boards, they must be phased out because they contribute to depletion of ozone from the Earth's upper atmosphere.

Each circuit board (see figure) is a double-sided printed-wiring board on which selected nonfunctional integrated-circuit packages have been mounted by representative surface-mount and pin-through-hole soldering techniques. By subjecting the board to the various cleaning processes and then examining the boards by various physical and chemical techniques, one can determine effects of chemical interactions among solder-flux residues, printed-wiring-board materials, and non-CFC cleaning fluids. The circuit board has been used thus far to evaluate 9 aqueous and 12 semiaqueous cleaning processes.

The insulating substrate for each board is either an epoxy-matrix/glass-fiber or a polyimide-matrix/glass-fiber laminate that measures 23 by 13 by 0.15 cm. Each board conforms to MIL-P-13994 and MIL-P-55110 specifications. The selection of parts and the placement of parts on a board provide the density necessary for monitoring the

performances of the cleaning fluids in the tight spaces between and under parts. Comb patterns with strips 0.4 mm wide spaced at intervals of 0.5 mm are placed under each nonfunctional surface-mounted part. The comb patterns

of the board. This circuit comprises dual-in-line-package (DIP) microcircuits and surface-mounted chip resistors and capacitors. This circuit is used to monitor the integrity of interconnections after cleaning; in particular, it is used to look



This **Circuit Board** includes both functional and nonfunctional components in configurations designed to yield representative data on the effects of cleaning with various fluids.

are used to monitor changes in the surface insulation resistance of the board caused by the cleaning processes and by environmental stresses like those associated with temperature and humidity.

A functional crystal-controlled oscillator circuit is included on a small section

for open and short circuits caused by cleaning and by environmental stresses.

This work was done by Robert Cummings and Fred Gross of **Goddard Space Flight Center** and Nitin Parekh and Mark Fan of Paramax Systems Corp. For further information, **write in 35** on the TSP Request Card. GSC-13658

Microstrip Antenna Generates Circular Polarization

Radiating elements are fed through coplanar microstrip feedlines.

Lyndon B. Johnson Space Center, Houston, Texas

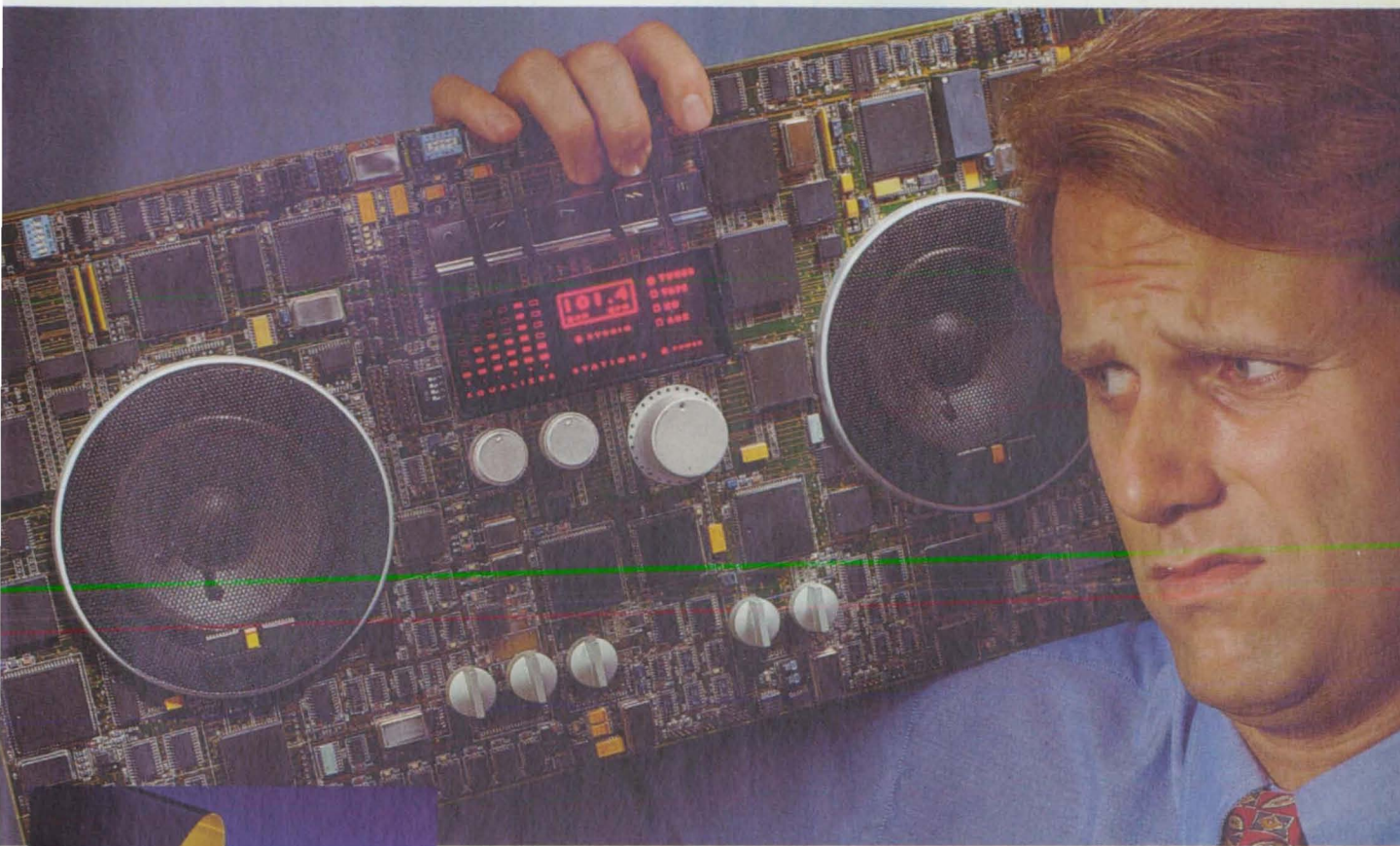
Figure 1 illustrates a microstrip array of four antenna elements that receives or transmits nearly perfectly circularly polarized microwaves over a band of frequencies near resonance. The four-element microstrip array can operate alone, as part of a larger fixed-aim array (see Figure 2), or as part of a lar-

ger array that includes electronically controllable phase shifters that effect electronic scanning of the radiated or received beam over a small range of angles about the broadside direction.

Microstrip feedlines are integral parts of the array and are laid out, along with the radiating antenna elements, in a

pattern that makes efficient use of the available area: the array fits within a square of side 0.7 times the free-space wavelength; this provides adequate margin for positioning and phasing of the four-element array as a phased sub-array within a larger fixed-aim or electronically scanned array. In addition, the

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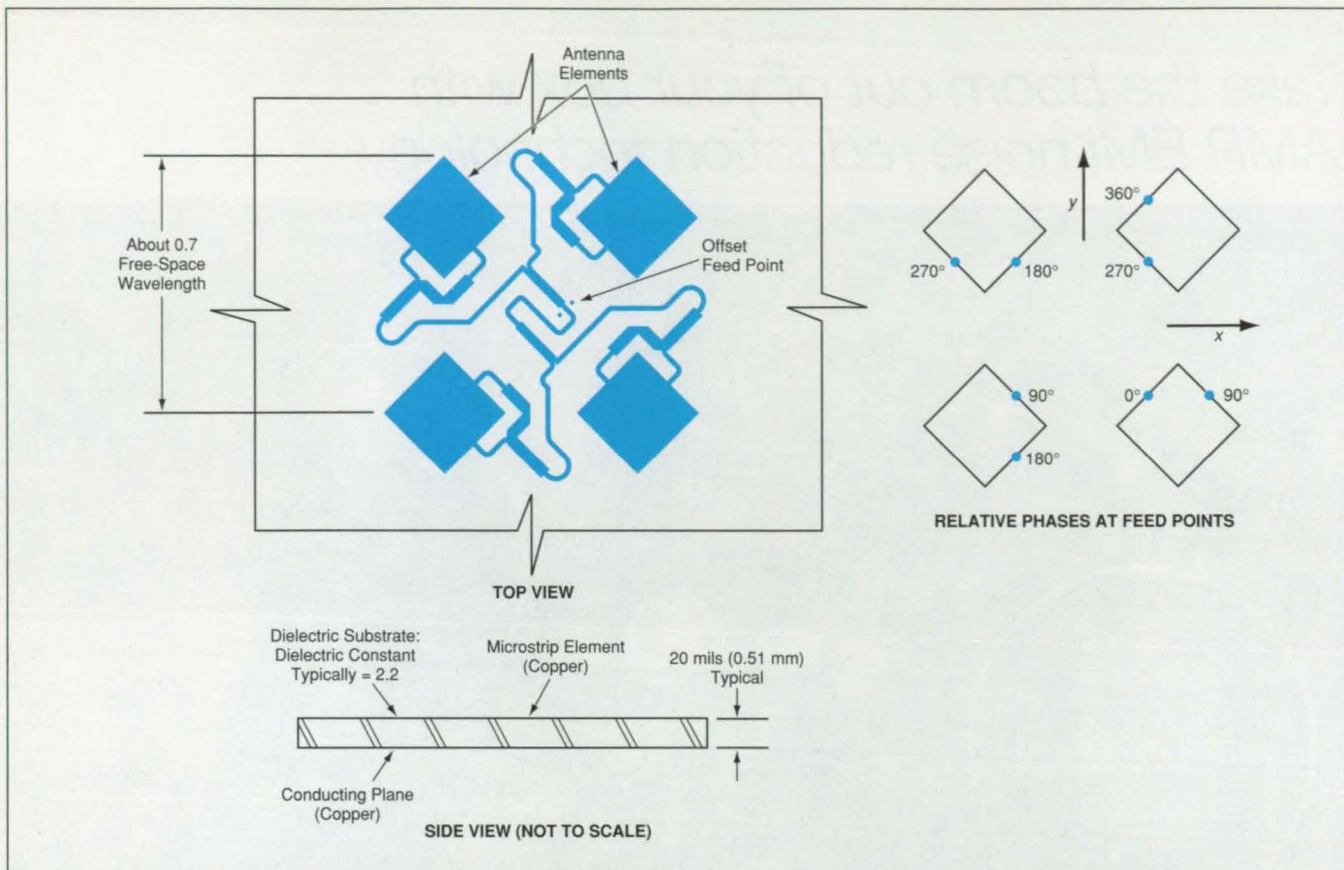


Figure 1. This **Microstrip Array**, including the feedlines, is designed to radiate in right circular polarization at a resonant frequency.

all-microstrip design (in comparison with a more complicated design that includes perpendicular coaxial feed probes, for example) simplifies fabrication.

Each square patch antenna element is excited at two feed points spaced 90° apart, at equal amplitudes in phase quadrature. This results in two orthogonal, approximately linearly polarized electromagnetic fields in phase quadrature, which add up to a single field in which the polarization rotates to the right; that is, each element radiates in nearly circular polarization. In addition, the four antenna elements are fed in phase quadrature with each other so that the composite field generated by all the elements rotates, making polarization of the composite field even more nearly circular.

The asymmetrical layout of the microstrip feedline is optimized at the resonant frequency to provide the equal amplitudes and quadrature phasing at the feed points. This layout includes power-dividing T-junctions and unequal-length, unequal-width feedline segments that match impedances and introduce different propagation delays that result in the desired quadrature phase relationships.

This work was done by Probir K. Bondyopadhyay of the National Research Council for Johnson Space Center. For further information, write in 79 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial

development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-21982.

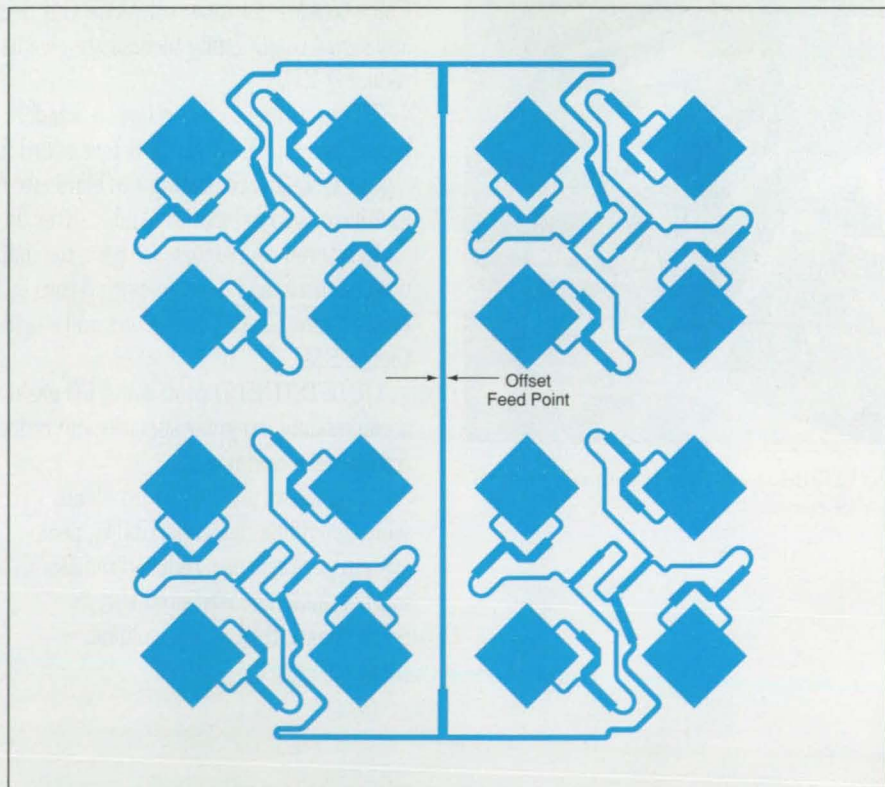
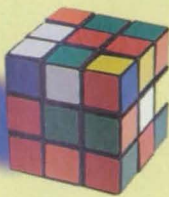


Figure 2. This **16-Element Array** comprises 4-element arrays like that of Figure 1.

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Microstrip Reflectarray Antennas With Mechanical Phasing

Antenna elements would be rotated to effect phase control for beam scanning.

NASA's Jet Propulsion Laboratory, Pasadena, California

Circularly polarized microstrip reflectarray antennas with mechanical phasing of individual antenna elements have been proposed. Like other microstrip reflectarray antennas, these would offer important advantages over paraboloidal-dish antennas; (1) they would weigh less and would have low profiles more suitable for mounting on vehicles and buildings and (2) like phased-array antennas in general, they would enable beam steering via phase control, without mechanical rotation of the entire antenna structures. Unlike some other phased-array antennas that have been developed in recent years, the proposed antennas would not include expensive beam-forming (power-dividing) transmission-line networks and/or phase-shifting circuits.

A basic microstrip reflectarray antenna includes a planar array of microstrip patches facing a feed horn, as shown in the upper part of Figure 1. Typically, the main parts of the patches are identical. Protruding from the main parts of the patches are short attached microstrip transmission lines, which are made in different lengths for differently located patches to provide delays required for compensation across the antenna aperture so that all patches radiate in the required polarization at identical phases into the desired beam direction. Often (as for communication between ground and satellite stations), circular polarization is used. Circular polarization can be achieved by use of two unequal-length delay lines orthogonally attached to each patch, as shown in the lower part of Figure 1.

In a microstrip reflectarray according to the proposal, phase compensation of the antenna elements would not be achieved by use of different-length delay lines. Instead, identical delay lines would be attached to the identical microstrip-patch antenna elements, and phase compensation would be achieved by rotating the patches and delay lines to different angles (see Figure 2). This technique of rotating the circularly polarized element to obtain required phases has been demonstrated. To make such adjustments possible, each microstrip-patch antenna element could be mounted on a miniature motor drive. The delay lines according to this concept would serve only as angular references for the rotations. The relative angle to which a given element should be set would

equal half the relative phase-delay angle required for that element.

This work was done by John Huang of Caltech for NASA's Jet Propulsion

Laboratory. For further information, write in 62 on the TSP Request Card. NPO-19670

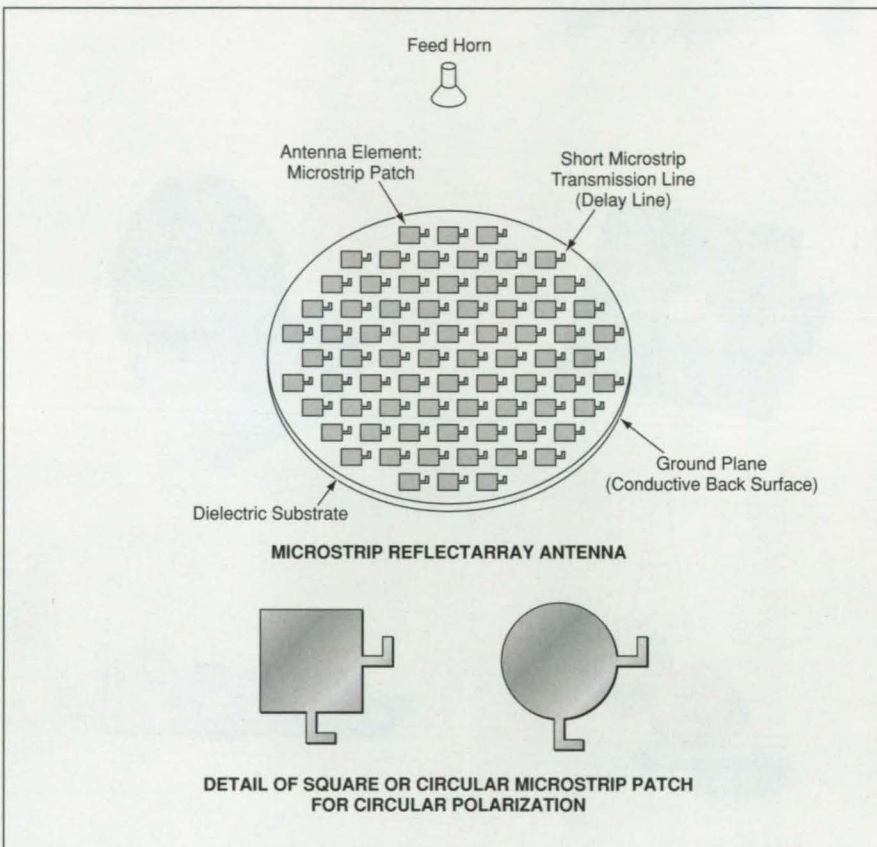


Figure 1. A **Basic Microstrip Reflectarray Antenna** contains an array of reflective microstrip-patch antenna elements. Phase compensation is provided by short microstrip transmission lines (delay lines) of various lengths.

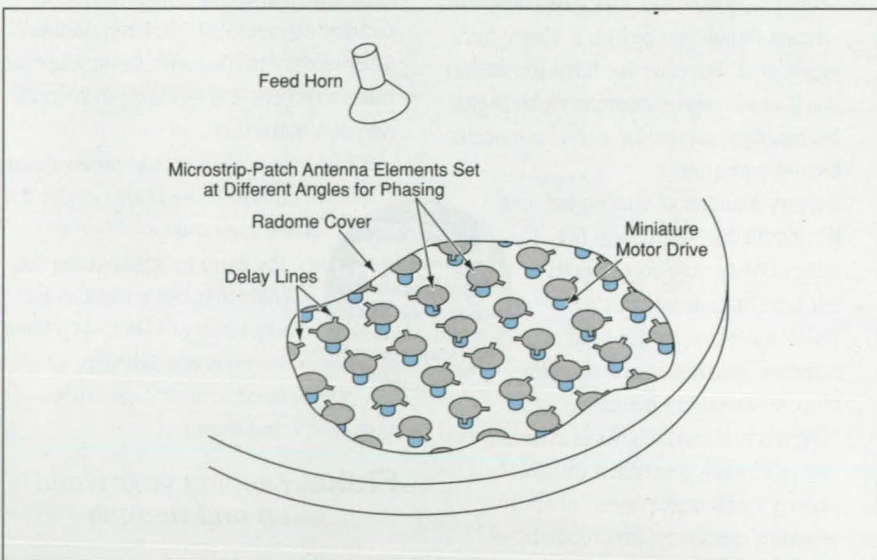


Figure 2. In a **Proposed Microstrip Reflectarray Antenna**, phase compensation would be achieved by differential rotation of identical microstrip-patch antenna elements.

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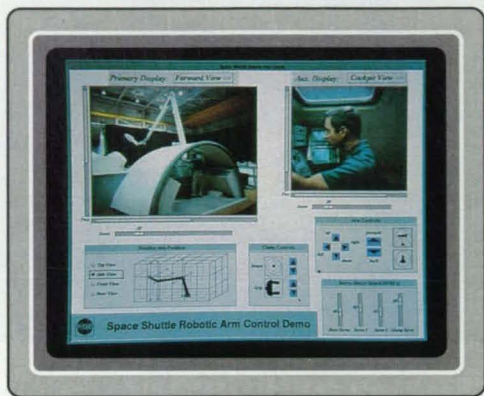
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Superconducting Notch Filter for 171 MHz

Performance exceeded that of much larger conventional notch filters made with copper.

Lewis Research Center, Cleveland, Ohio

A band-stop filter designed for a fundamental frequency of 171 MHz includes patterned high-temperature-superconductor (HTS) films grown on a sapphire substrate. The filter was constructed to demonstrate the utility of HTS on sapphire for miniaturizing and improving the performances of narrow-band filters for various communication systems. Developers have turned away from copper and toward superconductors for filter circuits because of the finite electrical resistance of copper and the consequent increase in surface resistance with frequency. These characteristics of copper and other normal conductors pose obstacles to further development in that they necessitate the use of undesirably large filter components to obtain a given level of performance and limit the performance achievable at any size.

The filter was configured as a spiral resonator coupled to a transmission line with an impedance of 50 Ω . The spiral resonator was patterned in an HTS film on one sapphire substrate, while the transmission line was patterned in copper film on another sapphire substrate. The substrates were assembled with the resonator and the transmission line in the same plane. The coupling between the resonator and transmission line could be varied by displacing them with respect to each other. The foregoing assembly was sandwiched between two ground planes implemented as HTS on sapphire substrates. Excluding connectors, the size of the filter was only 2.4 by 2.2 by 0.8 cm.

The filter exhibited an insertion loss of less than 0.1 dB at the design frequency. At one coupling setting, the rejection band was characterized by a notch depth of 120 dB and a 3-dB bandwidth of 230 kHz. When the filter was set for somewhat stronger coupling, the notch depth increased to 28 dB, and the 3-dB bandwidth increased to 1.1 MHz. These selectivity parameters indicate performance an order of magnitude better than that achievable with conventional copper filter circuits. Further improvements in performance and miniaturization are expected to occur with the use of HTS films on both sides of sapphire substrates.

This work was done by Erwin Belohoubek and Alberto Pique of Neocera, Inc., and David Kalokitis of Sarnoff Research Center for Lewis Research Center. For further information, write in 55 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-15875.

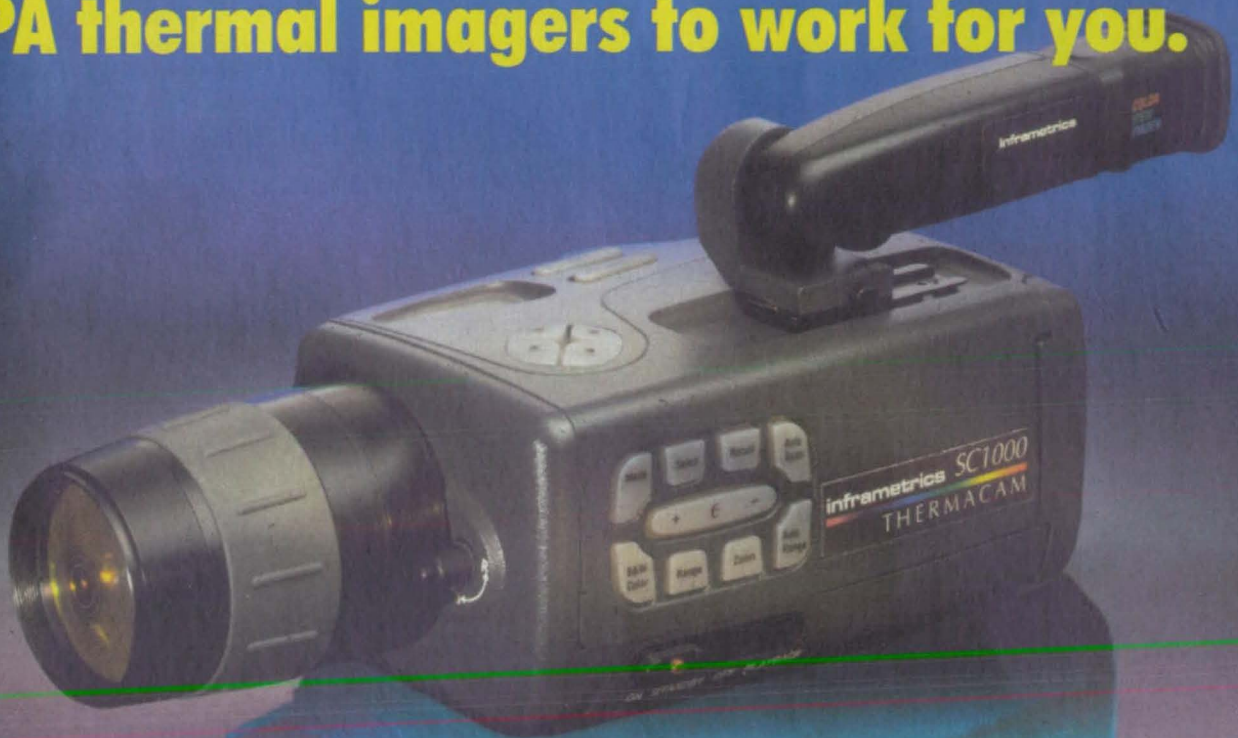
Improved Modeling of Discontinuities in a Transmission Line

A nonlinear least-squares technique fits model parameters to measurement data.

*NASA's Jet Propulsion Laboratory,
Pasadena, California*

An improved method of mathematical modeling of multiple discontinuities in a transmission line has been developed. The impetus for this development was a need to diagnose crimps and other discontinuities in a slightly damaged

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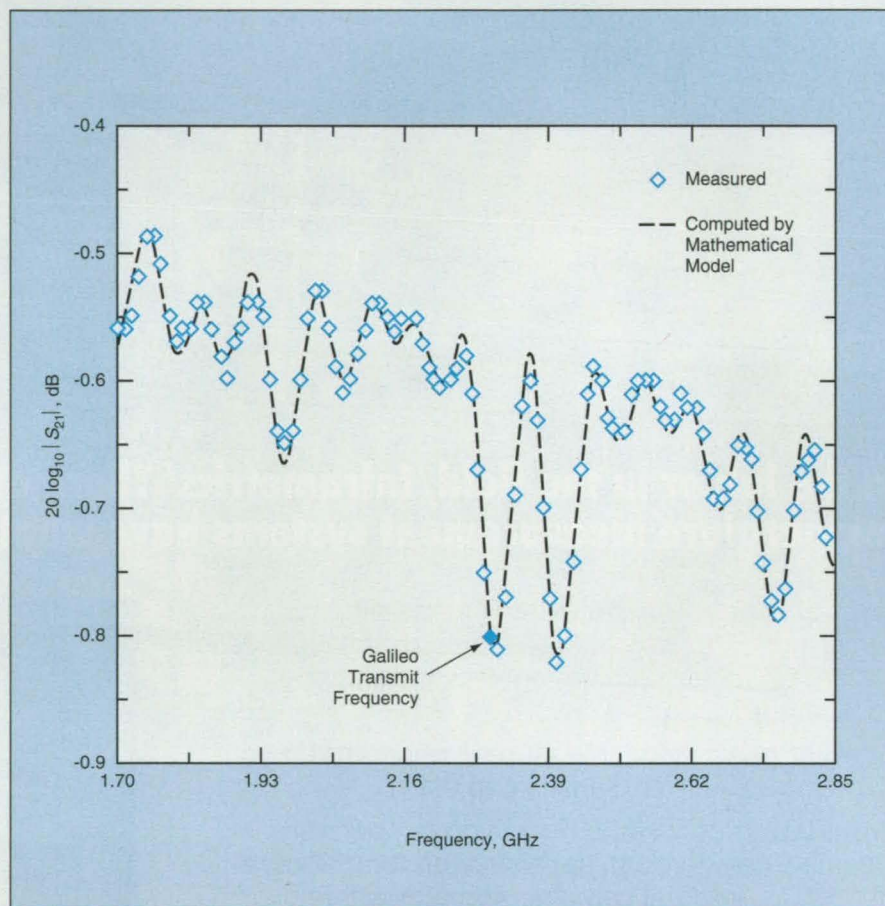
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coaxial cable that carries 2.295-GHz signals to an antenna in the Galileo spacecraft. The method is just as applicable to coaxial cables and other transmission lines (including waveguides) in terrestrial radio systems.

Some element of a priori assumption followed by trial and error is inevitable in any mathematical-modeling situation. However, the role of trial and error is reduced, in this method, by using a nonlinear least-squares procedure to adjust the parameters of the mathe-

lossy-transmission-line submodels. Each discontinuity or intervening length of transmission line is represented as a two-port subnetwork, and the transmission line is represented as the two-port network that is formed by cascading the subnetworks.

The S-parameters of the network (the cable) are computed by cascading the S-parameters of the subnetworks in a progression along the cable until all subnetworks have been included. Next, using the nonlinear least-squares tech-



This Plot Shows a comparison of theoretical and measured insertion losses.

matical model of the transmission line to make the input/output behavior of the model consistent with S-parameters (transmission and reflection coefficients) derived from time- and frequency-domain measurements of the input/output behavior.

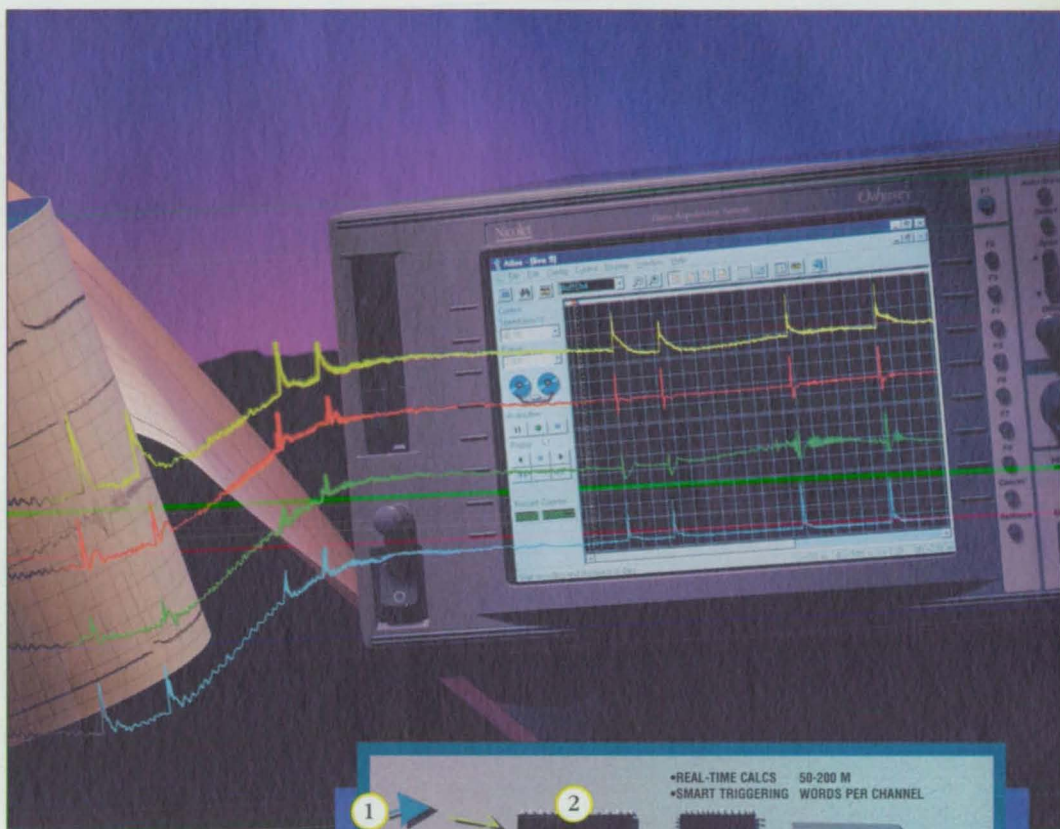
The modeling process begins with determining the approximate locations of discontinuities from time-domain measurements and from prior knowledge of potential discontinuities at bends, crimps, connectors, and cable clamps. The discontinuities are represented by equivalent circuit elements in the form of shunt susceptances and the intervening lengths are represented by

nique, the susceptances of the continuities and the lengths of the transmission-line segments are adjusted to make the computed S-parameters converge toward the measured S-parameters (see figure). In the least-squares procedure, the parameters are kept within specified bounds. Moreover, in adjusting the lengths of the segments, the sum of lengths is constrained to equal the actual length of the cable.

This work was done by Tommy Otoshi of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 90 on the TSP Request Card. NPO-19759

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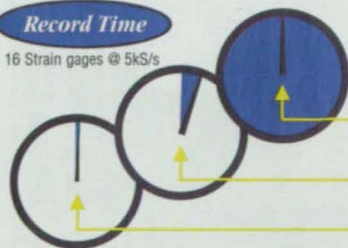


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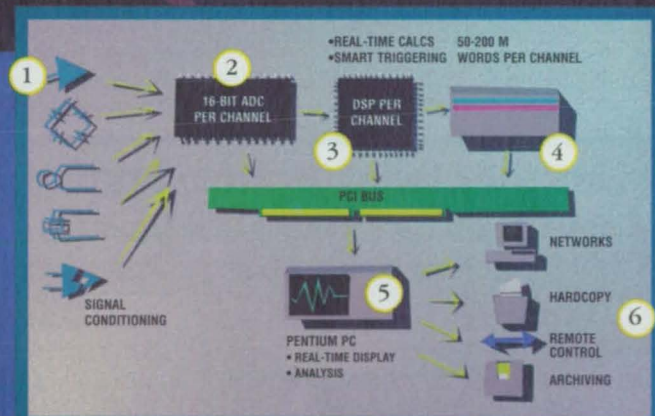
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Reducing Leakage Currents in a Bipolar Battery

Gas and electrolyte are shared among cells via a high-resistance manifold.

Lewis Research Center, Cleveland, Ohio

A proposed design concept for a nickel/hydrogen bipolar battery provides for reduction (in comparison with older designs) of the leakage electrical currents that unavoidably flow along the paths used for sharing of electrolyte and gas among cells. "Bipolar" as used here means that the interconnection between adjacent cells in series is an electrically conductive wall between electrodes of opposite polarity. To minimize leakage currents, the electrolyte (a 31-percent aqueous solution of KOH) in each cell can be sealed off from that in the other cells, but hydrogen gas must be allowed to flow freely among the cells. An effective design that keeps the cell electrolytes separate while allowing gas to

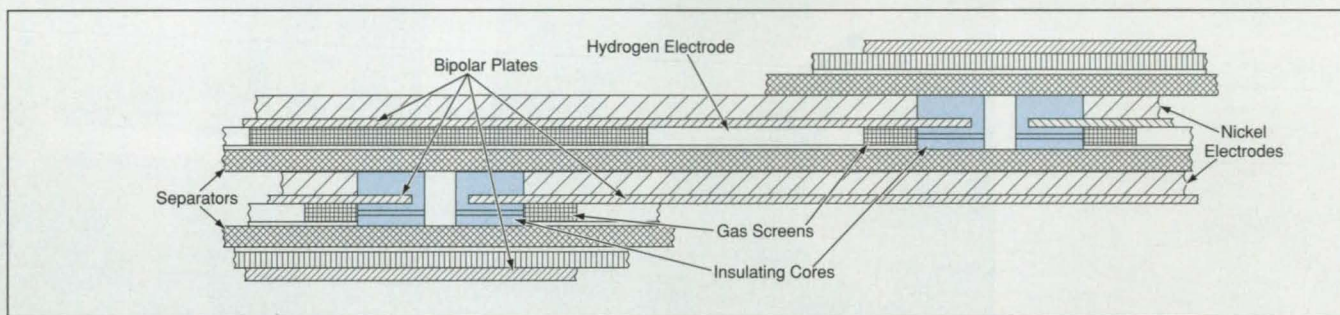
flow among cells in a separate manifold is complex and makes the battery too heavy and large for some applications.

Thus, the size, weight, and complexity of the battery can be minimized by a design in which all cells share electrolyte, but then the problem becomes one of reducing leakage currents to tolerable levels. According to the present concept, the cells would share electrolyte and gas via an intrabattery manifold that would comprise both intercell passages and portions of the cells (see figure). The shape and dimensions of the manifold would be chosen to maximize electrical resistances and thus minimize leakage electrical currents along the electrolyte-flow paths. It has

been estimated that the leakage currents in a battery of the proposed manifold design would be about 1/20 of those in a battery of simplistic design in which electrolyte was shared via small holes between cells.

This work was done by John C. Hall of Space Systems/Loral for **Lewis Research Center**. For further information, **write in 94** on the TSP Request Card.

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Holes Are Off Center and Staggered through the bipolar stack to maximize the electrical resistance of the manifold. A gas-screen space behind each negative electrode is utilized to accommodate part of the high-resistance manifold without having to increase the weight or volume of the battery.

"Bed-of-Nails" Approximate Version of a Choke-Ring Antenna

Weight, difficulty of fabrication, and cost are reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

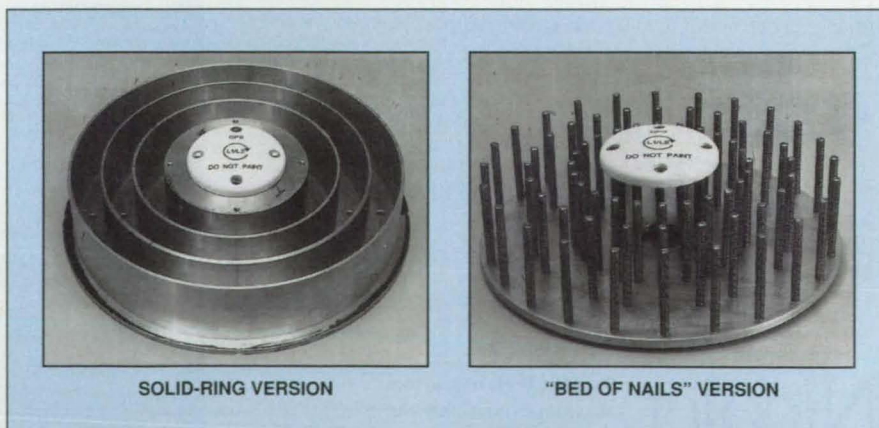
A "bed-of-nails" version of a choke-ring antenna has been found to perform about as well as does the original version made from concentric solid metal rings. In comparison with the solid-ring version, the bed-of-nails version offers advantages of lower weight, greater ease of fabrication, and lower cost.

In principle, the "nails" in the bed-of-nails version could be nails, but threaded rods (see figure) are probably more practical. The "nails" in the bed-of-nails version are positioned at equal circumferential intervals around concentric circles that correspond to the rings of the solid-ring version. To ensure that the signal to be handled by the antenna will be affected by each circle of "nails" in approximately the same manner as that of the corresponding solid ring, the circumferential intervals must be much smaller

than the wavelength of the signal.

This work was done by Donovan J. Spitzmesser of Caltech for **NASA's Jet**

Propulsion Laboratory. For further information, **write in 48** on the TSP Request Card. NPO-19801



The "Bed-of-Nails" version of this choke-ring antenna performs comparably to the solid-ring version. Each circle of threaded rods ("nails") corresponds to one of the solid rings.

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Compensating for Fading in K_a-Band Data Communications

Data rates would be adjusted to provide adequate link margins.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed mobile/satellite K_a-band data-communication system would include subsystems that would adjust data-transmission rates to compensate for fading associated with attenuation of signals by rain and by shadowing. Heretofore, it has been standard practice to compensate for such fading by adjusting transmitter power levels.

The system would use data rates of 9.6, 4.8, and 2.4 kb/s. The basic idea is to select the highest one of these rates that is consistent with the requirement to maintain, under worst-case assumptions, a link margin (defined below) above a minimum specified level of 3 dB. Customarily, "link margin" denotes a

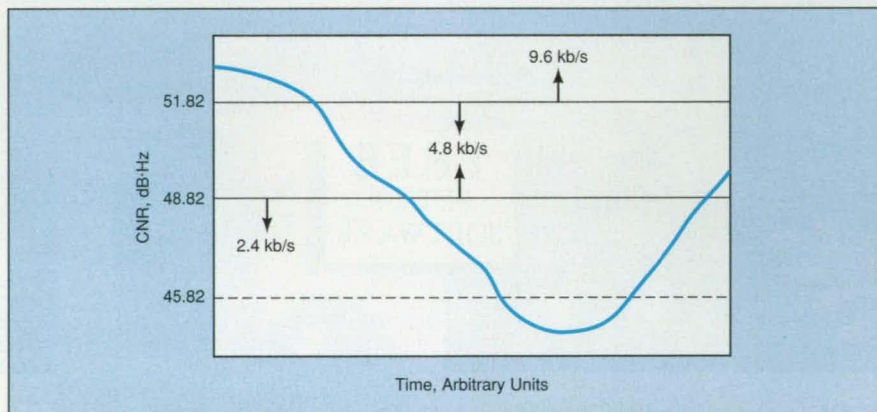
logarithmic (decibel) measure of the signal power beyond that needed to ensure performance at some baseline level. For a fixed power, performance can be improved (in the sense that the bit-error rate can be decreased) by decreasing the data rate. In other words, one can trade the data rate against the link margin.

Each terminal in the system would contain one of the subsystems that would calculate the required adjustments in data rates. The subsystems would estimate attenuation levels and link margins from the measured levels of signals received from the other terminals with which their terminals were attempting to communi-

cate. They would compare their estimates with known (threshold) levels to determine whether increases in data rates could be tolerated or whether decreases in data rates were needed to maintain adequate link margins. Data rates would then be changed accordingly.

The figure illustrates an example of switching of data rates to maintain at least a 3-dB link margin. Initially, the data rate would be 9.6 kb/s, and this rate could be tolerated as long as the carrier-to-noise-density ratio (CNR) remained above 51.82 dB-Hz. As the CNR passed below 51.82 dB-Hz, it would be necessary to switch to a data rate of 4.8 kb/s to maintain at least 3 dB of link margin. Similarly, it would be necessary to switch to a data rate of 2.4 kb/s when the CNR passed below 48.82 dB-Hz. When the CNR passed below 45.82 dB-Hz, adequate link margin could not be guaranteed. Of course, one could use the data rate of 2.4 kb/s all the time to ensure maximum availability of the communication link, but this low data rate would not be adequate for transmitting high-quality voice communications.

This work was done by Edgar H. Satorius, Loretta H. Tong, and Barry K. Levitt of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 31 on the TSP Request Card. NPO-19821



The **Data Rate Would Be Switched** to maintain a least a 3-dB link margin as the carrier-to-noise-density ratio (CNR) passed above or below either of two threshold levels (51.82 or 48.82). In the region below the dashed line, communication would be deemed unreliable because the link margin there would be < 3 dB.

Neural-Network Guidance System for a Mobile Robot

The robot would compute its position from proximity-sensor readings.

Lyndon B. Johnson Space Center, Houston, Texas

An electronic sensing and control system is being developed for use in guiding a mobile robot through hallways and rooms in a building. The system was designed for the Courier robot — a mobile robot that serves as a test bed for robotic technology and for studying interactions between humans and robots in an office environment.

The system would include five ultrasonic sonar proximity sensors, which

would measure distances to nearby walls and other objects at various angles with respect to the body of the robot. A data-processing subsystem containing electronic neural networks would process these distances to compute the horizontal position (x, y) and the orientation or heading (θ) of the robot (see Figure 1). Unlike in some prior robotic guidance systems, it would not be necessary to use bar-

code targets and/or active beacons that the robot could recognize to determine its position, and it would not be necessary to use highly precise odometry to track movements between recognizable targets. Instead, the neural networks would be trained to recognize the surroundings from the sensor readings, and low-precision odometry would suffice for navigation between recognized locations.

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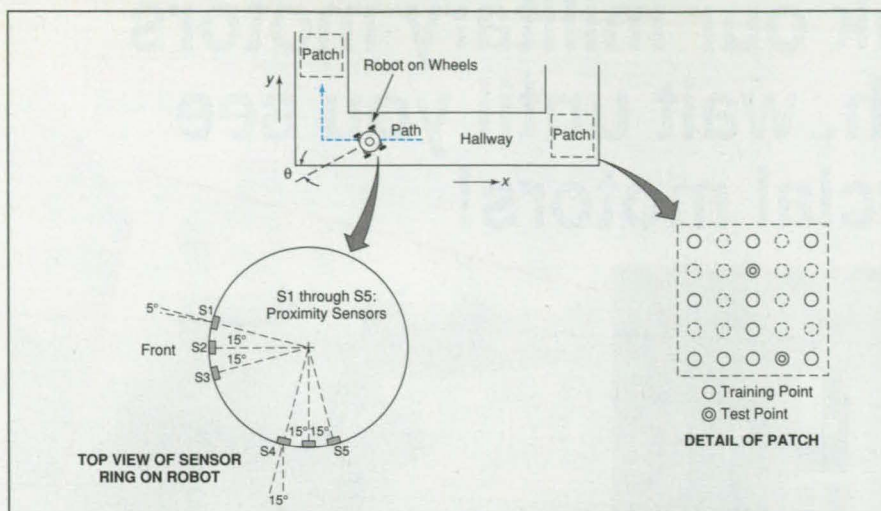


Figure 1. **Proximity Sensors** on the robot would measure distances to nearby walls. The robot would compute its position and orientation (x, y, θ) from the sensor readings.

There would be three independent back-propagation-learning neural networks; one each for x , y , and θ . Each network would contain three layers; a 5-node input layer, a 45-node hidden layer, and a single-node output layer (see Figure 2). The neural-network approach is proposed for this system because electronic neural networks are high-speed parallel-processing circuits modeled after the manner in which neurons are connected in the human brain. These circuits have the ability to map (learn) the functional relation-

ships between input and output sets of data — in this case, the functional relationships between proximity-sensor readings and (x, y, θ) coordinates.

The neural networks would be trained by use of designated areas, called "patches," at a few locations in the building. At each of several locations within a patch, proximity-sensor readings would be taken with θ set at each of the 21 increments of 1° in a total angular range of $\pm 10^\circ$. The sensor readings (inputs) and the known x, y, θ coor-

dinates (desired outputs) would thus constitute the input/output pairs of data that would be used to train the neural networks to recognize the surroundings and determine its position and orientation when in a patch.

The ability of the system to determine x and y within approximately 1 cm was demonstrated by computer simulation of the neural networks, using actual sensor data. However, initially, inconsistencies in data generated from the readings of the particular sensors used on the Courier robot made it impossible to train the θ neural network with only 5 sensor readings. In one promising alternative approach, the number of input nodes of the θ neural network was increased to seven; the five sensor outputs were fed to five of the input nodes as before, and x and y as computed by the other two neural networks were fed to the other two nodes. This approach enabled the system to determine θ with a root-mean-square error of only 0.414° at test positions (different from training positions) within a patch.

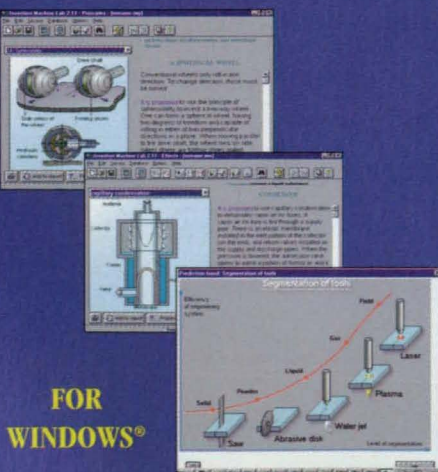
This work was done by Michael Lin, Naveed Quraishi, and Jeffrey Bye of Johnson Space Center. For further information, write in 88 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22318.

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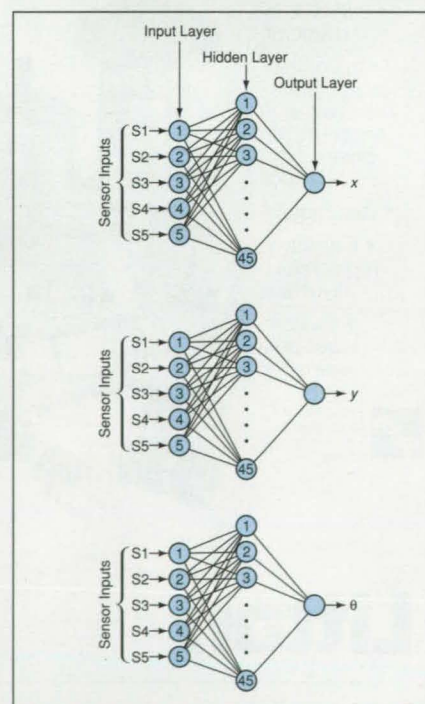


Figure 2. **Neural Networks** would be trained to compute x , y , and θ from sensor readings by use of training data acquired at designated positions within the patches.

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Eight stages of decimation would be implemented on a single chip.

NASA's Jet Propulsion Laboratory, Pasadena, California

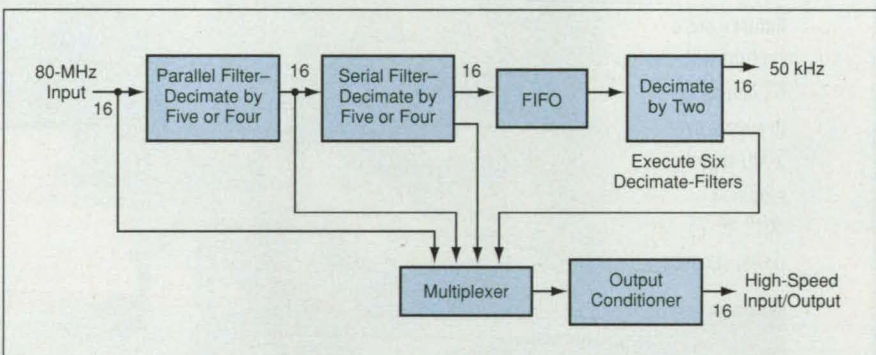
An application-specific integrated circuit (ASIC) for decimating radio signals that contain scientific data is undergoing development and is designed to be fabricated in a single GaAs-based chip. The ASIC would be a 16-bit digital filter that would receive an input signal at a sampling frequency of 80 MHz and would decimate the signal by 1,600 to obtain an output signal at a sampling frequency of 50 kHz, with a band-pass ripple of less than 0.1 dB.

In the ASIC, a memory with dynamic pointers would be used to implement digital delay lines. The pointers would be updated by use of dedicated adders.

decimate-by-five unit if the decimation-by-2⁶ unit is busy.

The decimation-by-2⁶ unit would contain six half-band filters, of which five would have 19 taps and one would have 51 taps. These filters would share a single multiplication/addition/accumulation unit. Accumulated values would be stored in memory. Successive decimation by two would result in operation of the last filters at relatively low frequencies.

The filter coefficients input by the user would be stored in two register files. Pipelining would be used to maintain the 80-MHz cycle throughout and for best utilization of hardware resources. Two



Eight Stages of Decimation comprising two of decimation by 5 and one of decimation by 2⁶ would be implemented in a single integrated circuit.

Filtering and decimation would be effected, according to filter equations, as additions, multiplications, and accumulations of digitized signal levels that have been delayed by various amounts in the digital delay lines.

The ASIC would contain two decimation-by-five units plus a single unit that would perform six decimations by two (see figure). The first decimation-by-five unit would include three multipliers operating in parallel to accommodate the high input-data rate. However, sequential operation of the second decimate-by-five unit would be feasible at its lower input rate. Accordingly, the second decimation-by-five unit would contain a single addition/multiplication/accumulation unit that would execute serial versions of the parallel algorithms executed in the first decimation-by-five unit. Either or both of the decimate-by-five units can operate in a decimate-by-four mode. A FIFO (first-in first-out) register, with capacity of four 16-bit data elements, would hold the output of the second

control registers would define the operation sequence, depending upon whether the input to each filter was even or odd and depending on which filter was active. For speed and density, the circuit would be implemented in a 350K GaAs gate array.

There would be two outputs, one of which would be taken directly from the filters. A control register would determine whether to proceed through all six half-band filters or to take output from a point before the last filters. The other output would be taken through a multiplexer to a serial fiber-optic path; this output could be a replica of the 80-MHz input, of the final 50-kHz decimated signal, or of the signal at any intermediate stage of decimation.

This work was done by Jeff B. Berner and James E. Kowalski of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 96 on the TSP Request Card. NPO-19770

PID Temperature Controller With Fuzzy Logic

Fuzzy logic would be used to select controller parameters.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed temperature-control system would include a computer-assisted proportional, integral, and derivative (PID) controller that would regulate the power supplied to a small heater attached to a sample in a cryostat (see figure). The system would operate in the same manner as that of a traditional PID control system, except that the key PID parameters would be adjusted, from time to time, to optimize control performance in the sense of minimizing overshoot and settling time.

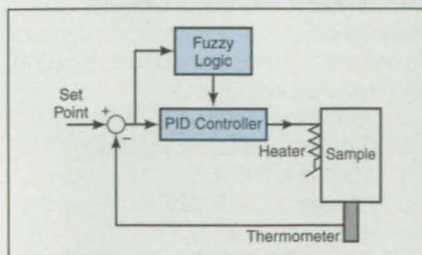
In the system, all signals would be discretized with a short sampling time T_0 , so that the governing equation for the controller would be the discretized version of the standard PID control equation; namely,

$$u(n) = G\{e(n) + (T_0 / T_i)$$

$$\sum_{i=0}^{n-1} e(i) + (T_0 / T_D)[e(n) - e(n-1)]\}$$

where n is an integer that denotes the present sampling period, $u(n)$ is the control signal that the system generates in the effort to maintain the temperature at a set point, $e(n)$ is the error signal (the difference between the actual and set-point temperatures), G is the gain, T_i is the integration time, and T_D is the differentiation time.

The gain and the integration and differentiation times are the key parameters that can be manipulated to optimize control performance. It is not easy to choose suitable values of these parameters, especially for set-point temperatures of only a few Kelvins. One major source of difficulty in choosing these values is the fact that in this temperature range, available cooling powers are small in com-



Fuzzy Logic would be used to adjust gain and characteristic times to optimize the performance of the PID controller.



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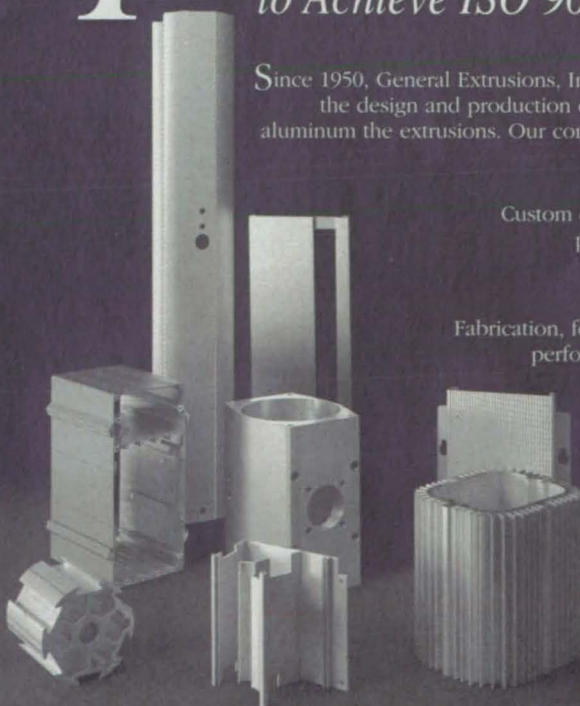
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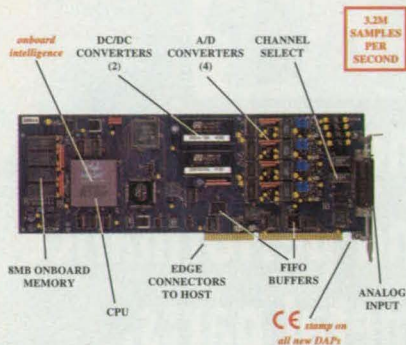
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parison with available heating powers, so that great care must be taken to prevent overheating.

In the proposed system, the values of G , T_i and T_D would be chosen according to fuzzy-logic rules summarized in tables as functions of the real-time error signal $e(n)$ and the real-time differential-error signal $de(n) \equiv e(n) - e(n-1)$. The proposed rules are derived from conventional wisdom in PID control theory. Because the system would heat easily but cool with difficulty, the parameter values for optimal control performance would have to be asymmetric with respect to positive and negative error values.

A computational simulation was performed to compare the performance of the proposed system with that of a traditional fixed-parameter PID control system in maintaining temperature in a cryostat near the ^3He critical point of 3.3 K. The results of the simulation showed that the proposed system could achieve faster settling and smaller overshoot.

This work was done by Inseob Hahn, Anthony Gonzalez, and Martin Barmatz of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 32 on the TSP Request Card. NPO-19969

Deconvolution Method for Reducing Multipath GPS Errors

Multipath errors are reduced to about one-tenth of previous values.
NASA's Jet Propulsion Laboratory, Pasadena, California

A method of signal processing has been proposed to reduce the deleterious effects of multipath propagation of the signals broadcast by Global Positioning System (GPS) satellites. GPS multipath propagation, caused primarily by reflection and diffraction of GPS signals from structures near GPS antennas, reduces the accuracy with which a GPS receiver estimates its position and/or attitude. The present signal-processing method could help satisfy a need for increasing accuracy in such applications as determining the positions and orientations of aircraft and spacecraft. The method involves estimation of the effects of multipath propagation on received GPS signals, followed by deconvolution to remove the estimated multipath effects. The method incorporates adaptive techniques for identification and estimation techniques, and leads to novel GPS-receiver architectures.

The mathematical derivation of the method begins with a finite-impulse-response mathematical model of a multipath channel with zero-mean additive white Gaussian noise. The received GPS signal entering this channel is modeled as a sinusoid with pseudorandom-code phase modulation. The signal emerging from the multipath channel (in effect, the signal entering the GPS receiver from the antenna) would be processed through a delay-lock discriminator, wherein the signal would be correlated with two reference sinusoids with delay offsets of $+\tau_d$ and $-\tau_d$ respectively. The correlator outputs would be demodulated by another reference signal provided by a carrier-phase-lock loop. The difference between these demodulated correlator outputs is denoted $g(\tau)$, where τ = the delay tracking error.

By use of a number of such delay-lock discriminators, one could obtain an approximation of a discriminator function $D(\tau)$. The mathematical modeling shows that $D(\tau)$ can be expressed as the convolution of $g(\tau)$ with the finite-impulse-response function $h(\tau)$. Knowing $g(\tau)$, one could use an appropriate digital-signal-processing algorithm to approximate $h(\tau)$ by discrete-time deconvolution form $D(\tau)$. Then the estimate of $h(\tau)$ could be used to deconvolve the pure GPS signal from the multipath-affected version that entered the receiver. Computational simulations have shown that processing by this method could reduce up to 35 multipath signals to typical levels between 1/10 and 1/100 of their original values. In simulations, the deconvolution method was able to reduce initial attitude errors of approximately 0.75°, to approximately 1 arc minute. The results were obtained assuming 1-m antenna baselines and 20 multipath-error signals.

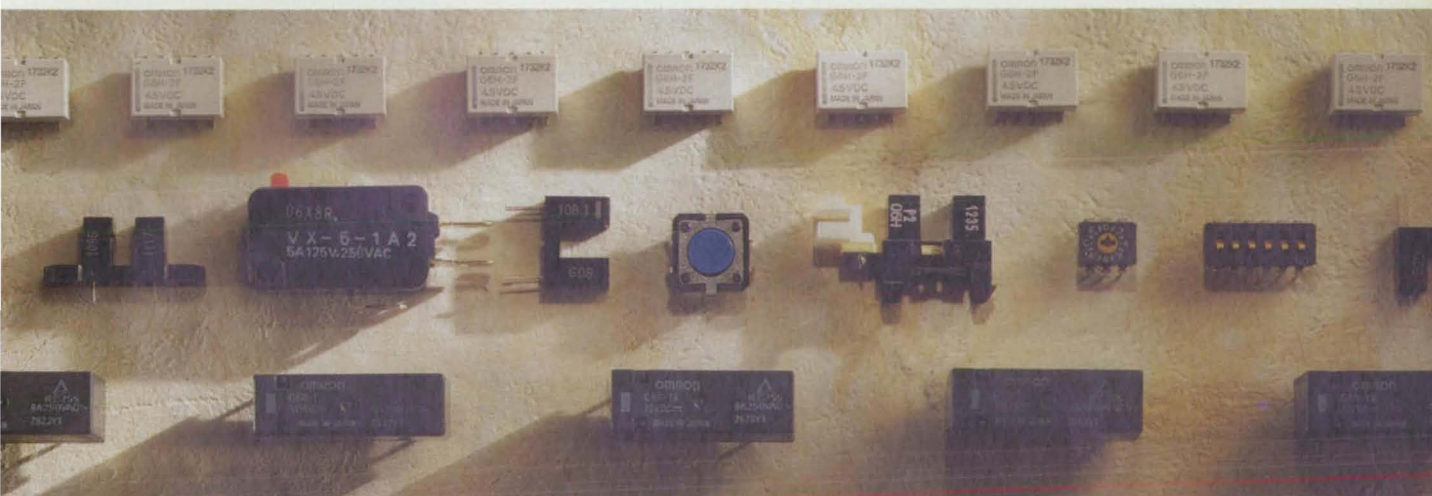
This work was done by Kenneth H. Lau of Caltech and Rajendra Kumar of California State University, Long Beach, for NASA's Jet Propulsion Laboratory. For further information, write in 15 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Larry Gilbert, Director
Technology Transfer
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Refer to NPO-19602, volume and number of this NASA Tech Briefs issue, and the page number.

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Enhanced Electrochemical Reduction of CO₂

CO₂ is decomposed into C and O₂ in a single-step process.

Lyndon B. Johnson Space Center, Houston, Texas

Preliminary experiments have shown that it may be feasible to remove carbon dioxide from air and decompose it into oxygen gas and solid carbon in a single-step electrochemical process. Such a process would be used to keep air breathable in a habitable closed environment like that of a spacecraft or submarine. Heretofore, some processes used for this purpose have been nonregenerative, involving circulation of air through chemical sorbent beds. Other processes have been regenerative and have involved multiple steps of (1) removal and concentration of CO₂ from the air, (2) reduction of CO₂ to CH₄ + H₂O or C + H₂O, and (3) electrolysis of the H₂O to generate O₂ and H₂.

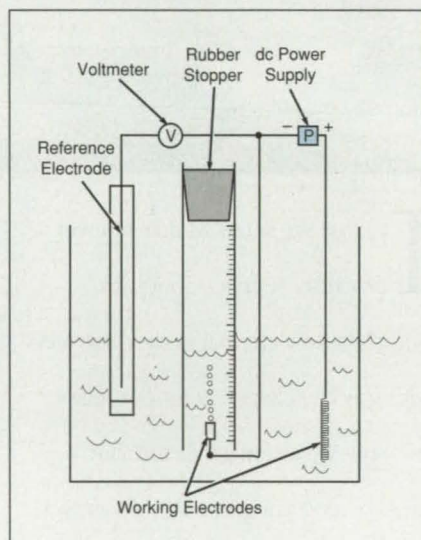
In principle, the electrochemical reduction of CO₂ directly to C and O₂ is thermodynamically favored over the reduction of protons to H₂ gas. However, previous efforts to reduce CO₂ electrochemically in aqueous solutions have yielded slow kinetics for the desired overall reaction $\text{CO}_2 \rightarrow \text{C} + \text{O}_2$ because of (1) the fast kinetics of competing reactions that yield products of intermediate oxidation state (e.g., CH₃OH and CO) and (2) the strong absorption and adsorption of the intermediate products.

In the experimental method, the electrolyte is a 25-percent solution of ethylene diamine in water. Unlike in some older processes, there is no need to concentrate CO₂ prior to electrolysis because ethylene diamine can absorb CO₂ directly from the atmosphere, up to a concentration of 1 mole of CO₂ per mole of ethylene diamine. The main chemical products of the electrolysis of CO₂ in ethylene diamine are C, O₂, and H₂.

It had been theorized that the kinetics that favor the desired overall reaction $\text{CO}_2 \rightarrow \text{C} + \text{O}_2$ could be enhanced by adding a soluble derivative of C₆₀ (buckminsterfullerene). The reason is that C₆₀ is highly electronegative and therefore might serve as an intermediary to transfer electrons to CO₂ both in the bulk of the electrolyte and in the vicinity of the electrode, thus preventing strong adsorption of the intermediate products on the electrode. Accordingly, the soluble compound C₆₀(N₂C₂H₅)₆ was prepared by stirring C₆₀ in ethylene diamine for about 1 day at room temperature. In experiments with Ag electrodes (see figure), it was found that in the presence of C₆₀(N₂C₂H₅)₆, the evolution of hydrogen is reduced; that is, the efficiency of production of the desired C and O₂ is increased. Some of the carbon is deposited on the

electrode surfaces, while some precipitates in the electrolyte.

This work was done by Rauof O. Loutfy and C. T. Lee of Materials & Electrochemical Research (MER) Corp. for Johnson Space Center. For further information, write in 84 on the TSP Request Card.
MSC-22279



This **Electrochemical Cell** was used in the experiments on the electrochemical reduction of CO₂.

Thermoelectric-Device-Aided Heat-Flux Gauges and Radiometers

These sensors could be used where liquid cooling is not practical.

Lewis Research Center, Cleveland, Ohio

Heat-flux gauges and radiometers of a proposed type would incorporate thermoelectric devices for active cooling. These sensors could be used to measure conductive, convective, and/or radiative heat fluxes in vacuum systems and other environments in which cooling with circulating liquids is impractical.

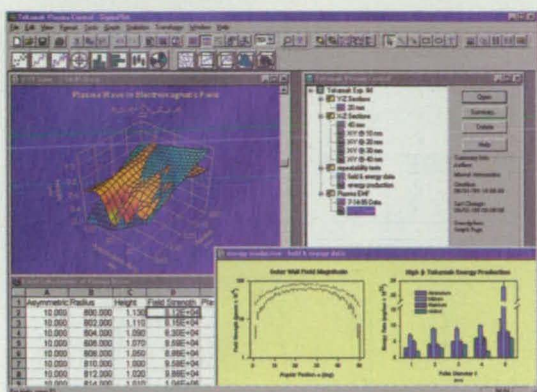
Active cooling is needed because accurate heat-flux measurements depend on maintaining sensor, test-piece, and/or adjacent guard surfaces at mea-

sured or specified temperatures. For example, in measuring insolation with a thermal radiometer, it is necessary to prevent convection, which could introduce an error into the measurement by diverting some of the heat flux from the radiometer. A thermoelectric device could be used to cool the radiometer to ambient temperature and thereby eliminate convection.

Sensors, thermoelectric devices, and test pieces could be mounted in a vari-

ety of configurations. In the example illustrated in the figure, a thermal radiometer would be mounted on a thermoelectric device on a heat-dissipating radiator, and thermocouples would be used to monitor the temperatures of the sensor and radiator surfaces. The power to the thermoelectric device would be controlled, in response to the thermocouple readings, to maintain the sensor surface at a set temperature. In this case, the sensor temperature would be

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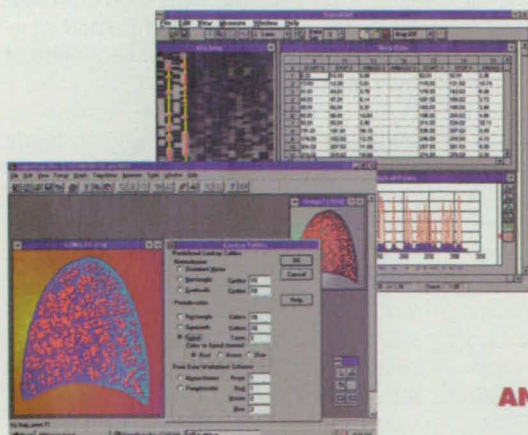
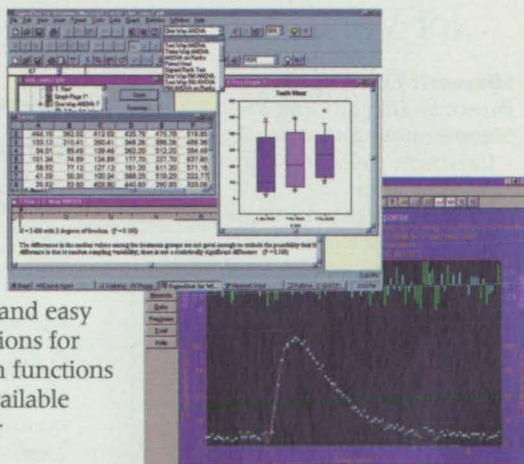


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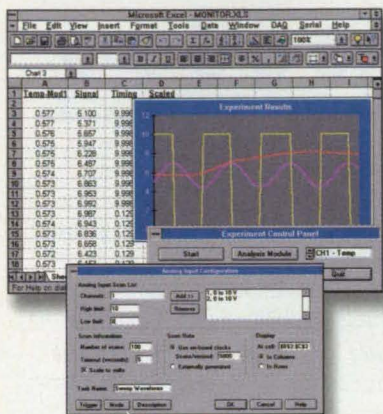
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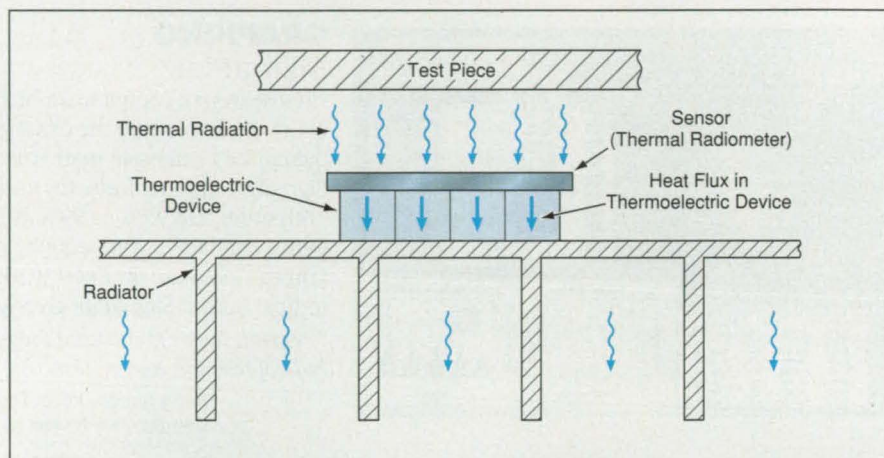
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lower than that of the test piece; in another case, the sensor temperature might be higher. An additional option would be to coat the sensor with the same material as that of the test piece, so that the radiative properties of the sensor and test-piece surfaces would be identical or at least sufficiently similar that these properties would not affect the sensor calibration and therefore would not have to be measured.

This work was done by Peter S. Merrill

of Rockwell International Corp. for **Lewis Research Center**. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-15837.



The **Thermoelectric Device** and the **Radiator** would provide active and passive cooling to maintain the sensor at the desired temperature.

Membrane Modules Separate Nitrogen From Carbon Dioxide

Rubbery polymer membranes permeate carbon dioxide preferentially over nitrogen.

Lyndon B. Johnson Space Center, Houston, Texas

Modules that contain thin membranes permeable by gases have been developed to remove nitrogen from gas mixtures that contain some nitrogen and that are rich in carbon dioxide. Such gas streams occur in some industrial processes and in some closed-circulation systems that revitalize air for breathing in enclosed habitats like those of submarines and spacecraft. Separation of nitrogen from carbon dioxide is necessary in air-revitalization systems because in all practical processes for conversion of carbon dioxide to oxygen, the equipment cannot function properly for long times when the nitrogen content exceeds 0.2 percent. The modules could also be used to remove carbon dioxide and hydrogen sulfide from natural gas and to concentrate carbon dioxide from smelter and flue gases.

The membranes used for the separation of nitrogen and carbon dioxide are more permeable to carbon dioxide than nitrogen. Passing a feed gas containing carbon dioxide and nitrogen across

such a membrane produces two gas streams. The nonpermeating gas stream is depleted in carbon dioxide and enriched in nitrogen, while the permeating gas is mainly carbon dioxide. The driving force for this separation is provided by the difference in the carbon dioxide partial pressure on the two sides of the membrane.

An indication of the achievable degree of separation is the membrane selectivity, which is the ratio of the permeabilities of carbon dioxide and of nitrogen through the membrane. The membranes in the prototype modules are made of Pebax® 4011 (or equivalent), which is a rubbery polyamide/polyether block copolymer. The selectivity of such a membrane is theoretically about 60, though the actual value is usually somewhat smaller and depends on process conditions. Although the selectivities of some glassy polymers are initially greater, rubbery polymers like this one, even with lower initial selectivities, are still prefer-

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able. This is because rubbery polymers are less susceptible than glassy polymers to plasticization by carbon dioxide and the resulting decreases in their selectivities.

The membrane used in the prototype modules is a composite comprising an ultrathin layer of the selective polymer coated onto a microporous support layer.

The membrane is wound into a spiral around a collection pipe and enclosed along with the pipe to form a module. Most of the prototype modules are 25 cm long and 4 cm in diameter and contain 650 cm² of effective membrane area.

The modules were tested with a feed stream of 97 CO₂/1 O₂/2 N₂ (numbers

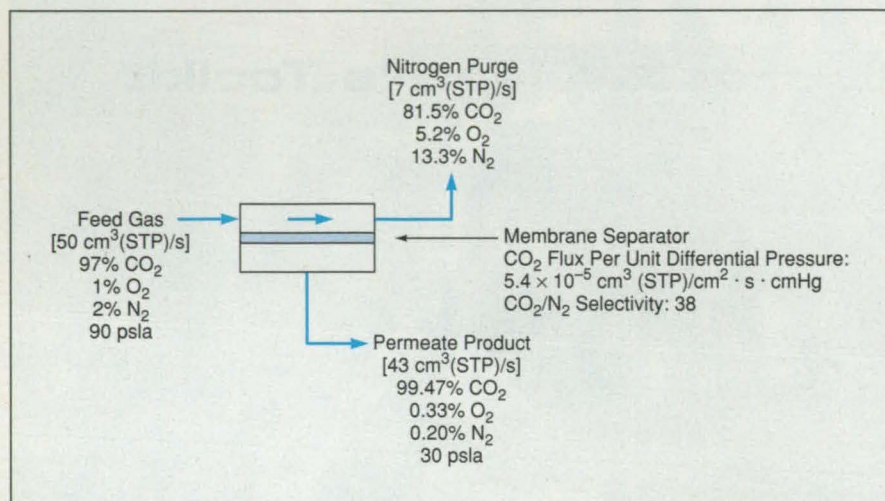
are in percent). The modules produced a carbon dioxide-rich permeate stream at a pressure of 30 psia (207 kPa) containing less than 0.2 percent nitrogen (see figure). Initially, the recovery of carbon dioxide was limited to the range 60 to 65 percent because of concentration polarization effects within the membrane modules. A modified module design reduced concentration polarization effects and improved performance.

This work was done by Richard Baker, Amulya Athayde, Huong Ly, and John Davidson of Membrane Technology and Research, Inc., for Johnson Space Center. For further information, write in 82 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to;

Ms. Tessa Ennals
1360 Willow Road, Suite 103
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Refer to MSC-22252, volume and number of this NASA Tech Briefs issue, and the page number.



The Performance Figures shown in this schematic representation of the operation of a polymer-membrane CO₂/N₂ separator module are based on the performances of prototype modules in experiments.

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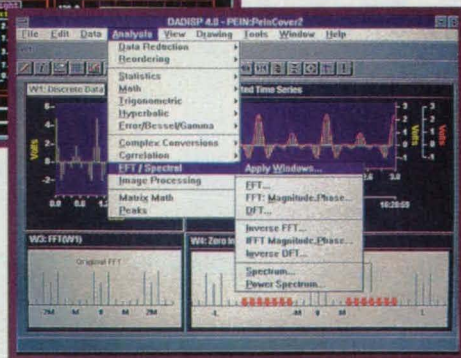
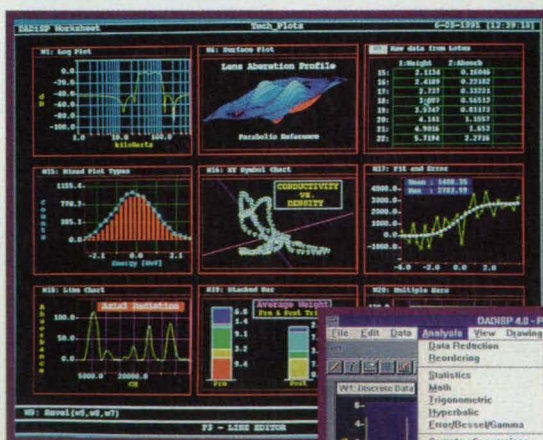
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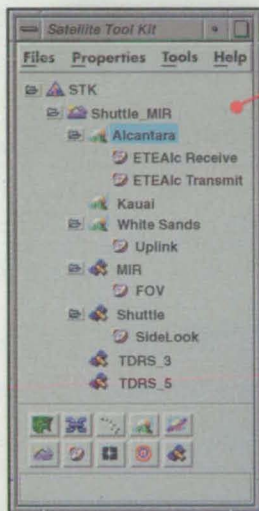
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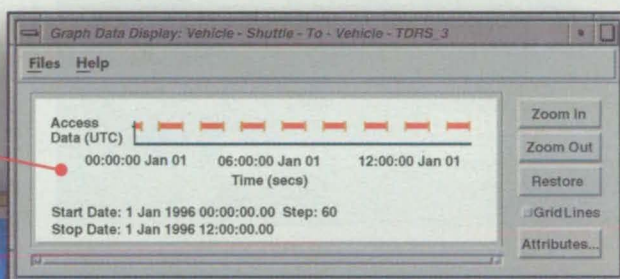
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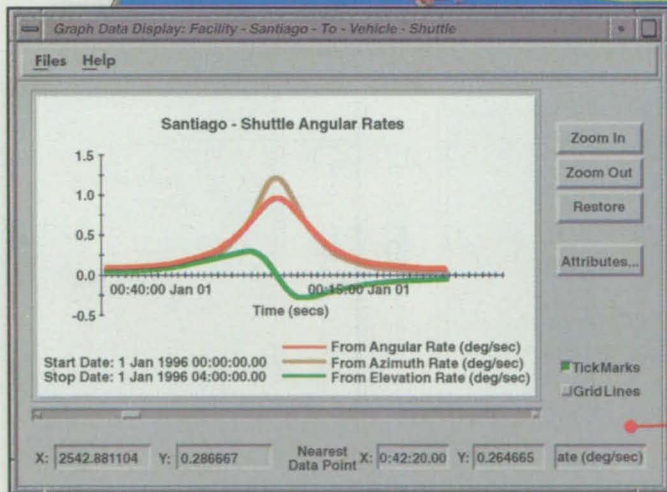


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3	40.358	61.941
4	40.377	61.885
5	40.401	61.769
6	40.431	61.685
7	40.466	61.600
8	40.506	61.517
9	40.552	61.434
10	40.604	61.352
11	40.663	61.271
12	40.727	61.191
13	40.799	61.112
14	40.877	61.034
15	40.963	60.957
16	41.056	60.882
17	41.157	60.808
18	41.267	60.737
19	41.386	60.668
20	41.514	60.601
21	41.652	60.538



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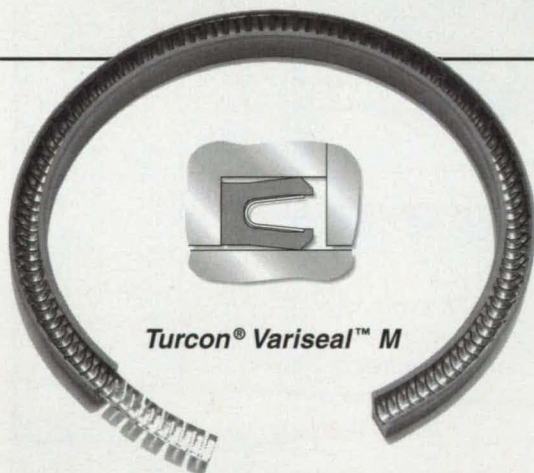
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Granules turn black in the presence of organic gases.

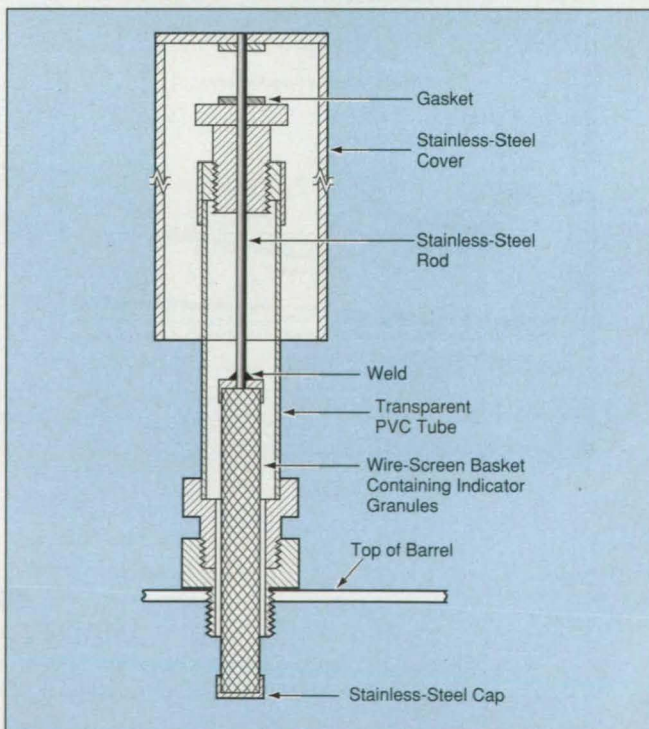
Lyndon B. Johnson Space Center,
Houston, Texas

The figure shows a device that provides a visual indication of the condition of a filter that is used to remove volatile organic compounds from air. The filter is a barrel filled with a carbon filter material that absorbs the volatile organic compounds until it becomes saturated. The device satisfies the need of maintenance technicians for a quick, easy way to determine whether saturation has occurred, without exposing themselves to the gases in the barrel.

The device includes a transparent plastic tube that is mounted on top of, and sealed to, the barrel. A wire-screen basket that holds granules of an indicator material is suspended on a rod that slides vertically in the plastic tube, with a gasket sliding seal between the rod and a plug at the top of the tube. During normal operation of the filter, the basket is lowered into the barrel just above the carbon filter material. For inspection, the basket is raised into view in the plastic tube, all without breaking the seal. The granules of indicator material turn black when exposed to organic gases, indicating that the carbon filter material has become saturated.

This work was done by Victor Dominguez, George R. Hackler, and Ron J. Gamboa of Lockheed Engineering and Sciences Co. for Johnson Space Center. For further information, write in 59 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22525.



The Wire-Screen Basket Containing Indicator Granules is normally kept lowered into the barrel but can be raised for inspection. The gasket prevents leakage of gas from inside the barrel.

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Li_xSiP_y Solid Electrolytes for Rechargeable Li-Ion Batteries

Lithium silicon phosphides with antifluorite crystalline structure may be superior solid-state electrolytes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lithium silicon phosphides Li_5SiP_3 and Li_6SiP_4 , which have antifluorite crystalline structure, are being investigated to determine their electrochemical properties. These compounds have been predicted to exhibit both high ionic conductivity and wide electrochemical windows (decomposition potentials > 4 V) at room temperature. If experiments show that Li_5SiP_3 and Li_6SiP_4 do, indeed, exhibit these properties, then these compounds could serve as superior solid-state electrolytes for rechargeable lithium-ion-based electrochemical cells. Batteries containing these electrolytes could be useful in applications in which high energy densities are required; such applications could include electric vehicles and load leveling.

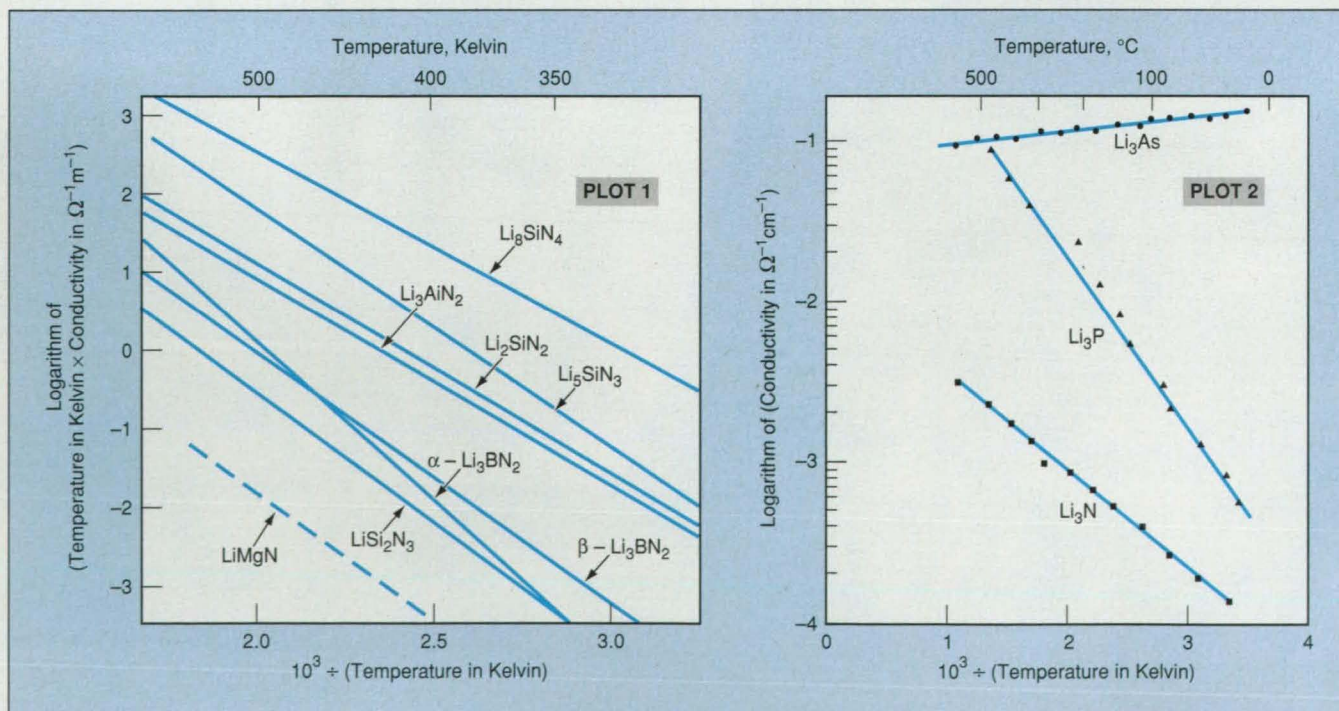
Solid-state electrolytes with both high ionic conductivity and high decomposition potential are needed for room-temperature solid-state Li-ion batteries.

Prior research has focused on lithium nitrides with layered structure (for example, Li_3N) or antifluorite structure (for example, Li_5SiN_4) as potential solid-state electrolytes. The room-temperature conductivity of Li_3N is high ($10^{-3} \Omega^{-1}\text{cm}^{-1}$), but its decomposition voltage is low (0.4 V versus Li/Li^+). As shown in plot 1 of the figure, the conductivities of lithium silicon nitrides of antifluorite structure increase with Li content; Li_6SiN_4 has the highest conductivity, ($10^{-5} \Omega^{-1}\text{cm}^{-1}$) at room temperature. The decomposition potential of lithium silicon nitrides of antifluorite structure (for example, Li_3SiN_2) has been measured to be ≥ 1.2 V. Recently, it has been observed that the room-temperature conductivities of lithium phosphides having a layered structure (for example, Li_3P , as shown in plot 2 of the figure) are greater than that of Li_3N by a factor of about 4. In addition, the decomposition potential of Li_3P is 2.2 V, which is more

than 5 times that of Li_3N . However, at present, the conductivities and decomposition potentials of lithium silicon phosphides of antifluorite structure remain unknown.

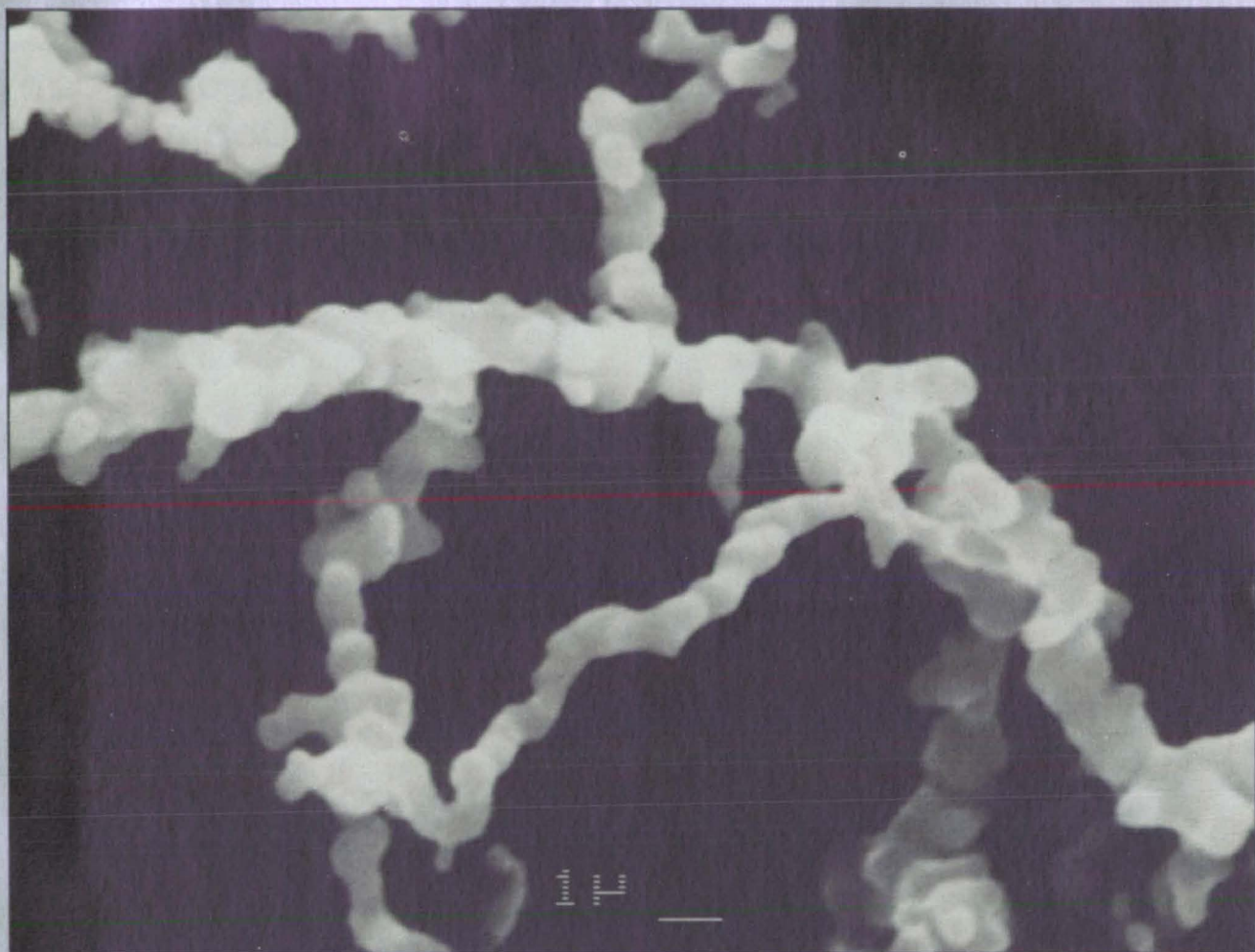
The following considerations give rise to the prediction that lithium silicon phosphides of antifluorite structure (in particular, Li_5SiP_3 and Li_6SiP_4) should both exhibit high conductivity and high decomposition potential at room temperature:

- From plot 2 in the figure, it is expected that the conductivity of Li_6SiP_4 would exceed that of Li_5SiP_3 . In addition, from plot 1, it is expected that Li_6SiP_4 should have the highest conductivity among the lithium silicon phosphides.
- Given that the decomposition potential of Li_3P is at least 5 times that of Li_3N , the decomposition potentials of the lithium silicon phosphides of antifluorite structure may be greater than 4 V. If the decomposition potential of the



These **Plots of Ionic Conductivities** of various lithium compounds lead to the expectation that the proposed solid electrolytes would have the desired high ionic conductivities.

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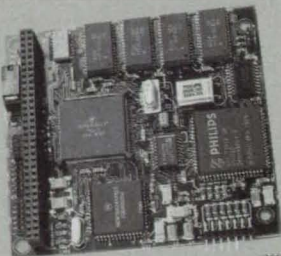
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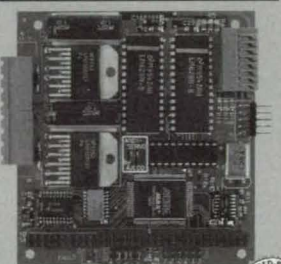
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antifluorite phosphides is > 4 V, then they will be stable against transition-metal oxides (for example, $\text{Li}_2\text{Mn}_2\text{O}_4$) now used as the cathode materials for lithium batteries. High decomposition potential will be most important in applications in which high potential is the prime requirement.

This work was done by Chen-Kuo Huang, Jeff Wolfenstine, and Subbarao Surampudi of Caltech for **NASA's Jet Propulsion Laboratory**. For further information, write in 53 on the TSP Request Card.
NPO-19684

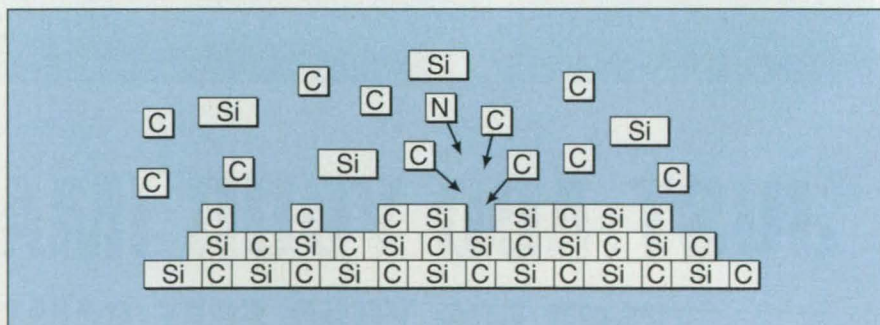
Chemical Vapor Deposition of Silicon Carbide With Controlled Doping

Ratio of SiC-precursor flows are adjusted to control dopant incorporation in growing SiC epilayers.

Lewis Research Center, Cleveland, Ohio

Silicon carbide (SiC) is emerging as a material of choice for fabrication of high-power and/or microwave-frequency semiconductor devices suitable for operation in high-temperature, high-radiation, and corrosive environments. Currently, the initial step in making SiC semiconductor devices is a process called chemical vapor deposition (CVD), which allows single crystal layers (epilayers) of varying electrical character to be grown. The SiC epilayers are produced in the CVD process by thermal decomposition of commercially available silicon-source and carbon-source gases onto boules-derived SiC substrates. The electrical character is tailored by the addition of dopants, impurity elements that affect the epilayer electrical properties, which are

Prior to this reported work, control over dopant incorporation for CVD SiC epilayers had been very limited. Reproducible doping was typically confined to a relatively narrow doping range, which has restricted SiC device performance to below theoretically predicted values. This doping range was recently greatly expanded by the NASA Lewis Research Center discovery that the ratio of the silicon-source flow to carbon-source flow during the CVD epilayer growth could be used to control the dopant incorporation and, therefore, the electrical properties of the growing SiC epilayers. This process, named "site-competition epitaxy," serves to expand greatly the doping range to produce much lower doped SiC epilayers than was previously possible. In addition, site-competition epitaxy can also be used to produce



This **Schematic Representation** of a site-competition epitaxy model illustrates carbon (C) outcompeting nitrogen (N) for the vacant C-lattice site of the SiC crystal, resulting in lower n-doping in the epilayer.

added during the CVD SiC epilayer growth by flowing either nitrogen (for n-type) or trimethylaluminum (for p-type). However, in order for the inherently superior high-temperature semiconductor properties of SiC to be realized in advanced electronic device applications, control over the electronic properties of the CVD SiC epilayers must be improved.

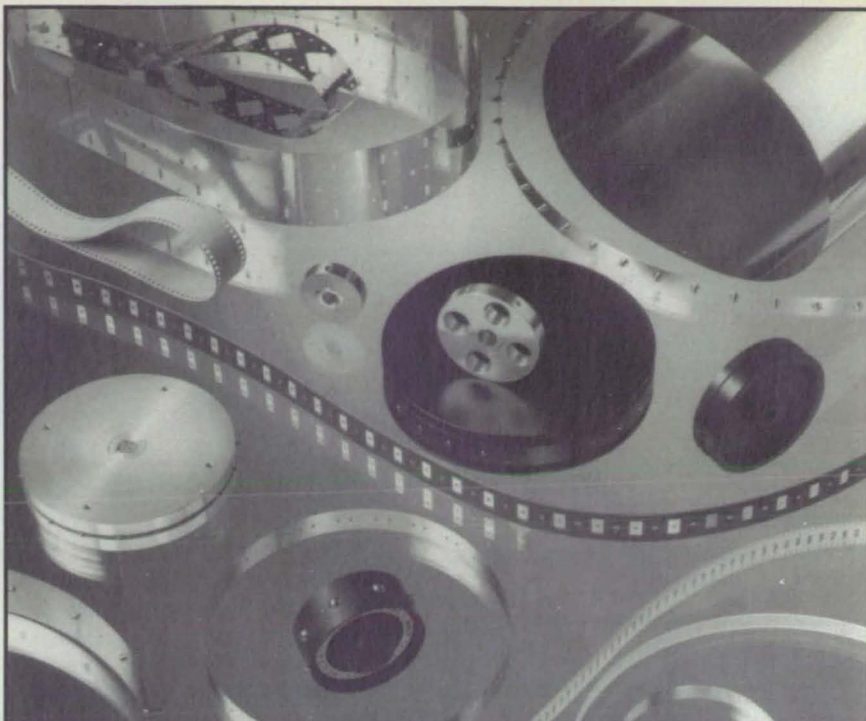
more highly doped SiC epilayers when more electrically conductive SiC epilayers are desired. Expanding the reproducible doping range to include lower concentrations has enabled the fabrication of multikilovolt SiC power devices, whereas the availability of higher doping concentrations has resulted in devices with improved performance because of lower parasitic resistances.

The site-competition epitaxy working model is based on the competition between the SiC-source gases and the dopant-sources for the available substitutional lattice sites on the growing SiC crystal surface. Dopant incorporation is controlled by appropriately adjusting the Si/C ratio within the growth reactor to affect the amount of dopant atoms incorporated into substitutional SiC crystal lattice sites. These sites are either carbon-lattice-sites (C-sites) or silicon-lattice-sites (Si-sites) located on the active growth surface of the silicon carbide crystal. Specifically, our model for site-competition epitaxy is based on the principle of competition between nitrogen and carbon for the C-sites and between aluminum and silicon for the Si-sites of the growing silicon carbide epilayer. The concentration of n-type (nitrogen) dopant atoms, which can occupy only C-sites, incorporated into a growing silicon carbide epilayer can be decreased by increasing the carbon-source concentration so that C "outcompetes" N for the available C-sites, as shown schematically in the figure.

Analogously, the amount of p-type dopant (aluminum) atoms incorporated, which can only occupy Si-sites, can be decreased by increasing the silicon-source concentration within the growth reactor so that Si outcompetes Al for the Si-sites (not shown).

In summary, the nitrogen donor concentration in the grown epilayer is proportional to the Si/C ratio during epilayer growth, whereas the aluminum acceptor concentration is inversely proportional to the Si/C ratio. Site-competition epitaxy was used (as depicted in Fig 1) to produce the very-low-doped epilayers required for the world's first 6H-SiC 2,000 V and 3C-SiC 300 V diodes. More recently, this novel growth technique has enabled the fabrication of SiC junction field-effect transistors (JFETs) that can operate at 600 °C in air for 30 hours. The site-competition epitaxy technique not only greatly expands the doping range for SiC but also allows for more reproducible dopant control within the previously attainable doping range. Additionally, site-competition epitaxy is the only known route to grow degenerately doped epilayers which result in ohmic as-deposited (i.e. unannealed) contacts for a variety of metals on both p-type and n-type SiC epilayers.

This work was done by David J. Larkin, J. Anthony Powell, and Lawrence G. Matus of **Lewis Research Center** and Philip G. Neudeck of Ohio Aerospace Institute. For further information, **write in 87 on the TSP Request Card.** LEW-15803



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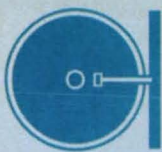
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Electronic Components and Circuits

Program Verifies Continuity in Microchip Conductor Layouts

The Chip Connectivity Verification (CCV) program examines proposed layouts of conductors in integrated-circuit microchips to verify electrical continuity between probe pads. CCV satisfies a need for comprehensive and efficient means of testing for geometric continuity (and thus, presumably, electrical continuity) of conductors before committing to fabrication and physical testing of designs that typically specify hundreds of metal strips, wires, vias, and other conductors on a chip. CCV works with the user in constructing paths of linked objects that represent the pads and the many conductors that connect them together. CCV is written in C++ in the UNIX environment. The chip design must be constructed by use of the L-EDIT program, and the design data file must be in CIF (CalTech Intermediate Form) format. CCV uses the UNIX programming tools Lex and Yacc to parse the CIF data and form the relevant data into object commands usable by the main part of the program. Once it has found equations for the lines that bound any two objects, the program can test intersection points of their lines. If they intersect within the boundaries, then the objects overlap and are presumably in electrical contact. By repeating this process, the program identifies an electrical path between different locations on a chip. Every line on every object is tested against all the lines on the chip.

This program was written by Josh Riley and George Patterson of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 16 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Larry Gilbert, Director

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Refer to NPO-19802, volume and number of this NASA Tech Briefs issue, and the page number.



Electronic Systems

Software for Automated Processing of Spacecraft Power Data

The TPower computer program was developed to automate and accelerate the recording, analysis, and reporting of operating parameters of solar photovoltaic and storage batteries in the power system aboard the TOPEX spacecraft. Prior to the development of this program, daily power-status reports were generated from manual calculations performed on data entered manually in tables; moreover, a time-consuming manual procedure was followed in recalling and processing past data from a standard tape record. Written in FoxPro 2.5 on a PC, TPower provides for automatic extraction of processed satellite data from a VAX flight computer and insertion of the data into a PC data base for use in analyzing trends and making predictions. The entire program is operated via a user-friendly graphical user interface. Daily status reports are generated automatically. Graphical and statistical reports are

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This work was done by Robert L. Sherwood and Fotios Deligiannis of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 27 on the TSP Request Card. NPO-19599



Physical Sciences

Software for Interactive Presentation of Planetary Data

The Welcome to the Planets™ computer program provides a multimedia display of data on the planets of the Solar system. The data were derived from various NASA missions and compiled from the Planetary Data System, the Public Information Office, and the United States Geological Survey. The data are supplied as animated images, captions with audio, and a glossary. Each datum in the compilation was peer-reviewed to insure the accuracy of the facts and images presented. The program was designed to serve as a

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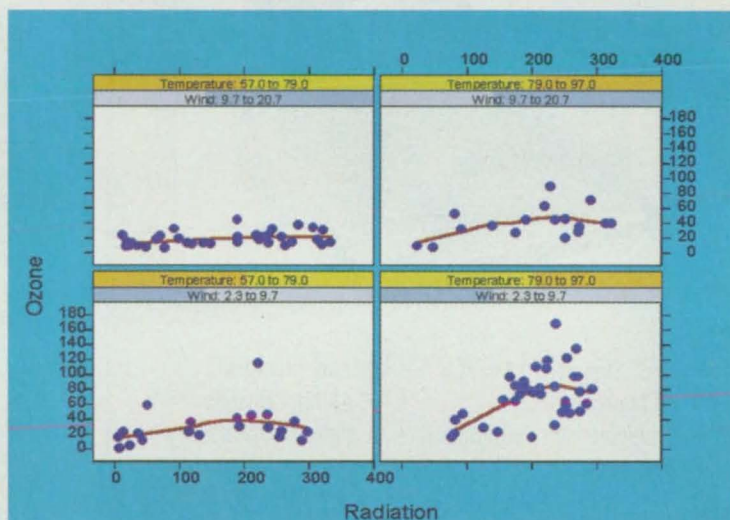
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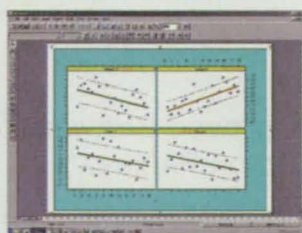
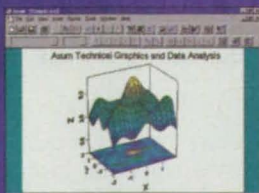
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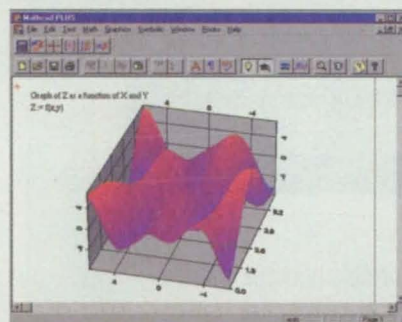
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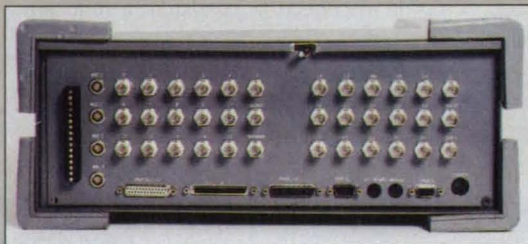
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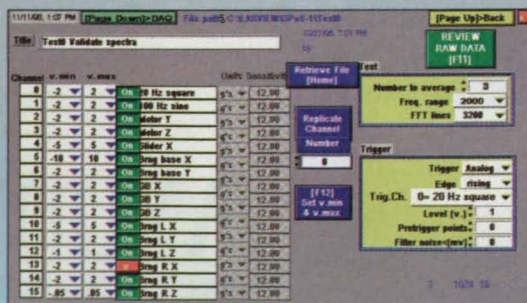
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This program was written by Michael D. Martin, David S. Hecox, and Brian Howard of Caltech for NASA's **Jet Propulsion Laboratory**. For further information, **write in 21** on the TSP Request Card.
NPO-19804

Software for Precise GPS Calculations

The GIPSY OASIS II computer program accepts data collected by a permanent worldwide network of more than 100 Global Positioning System (GPS) reference receivers and continuously processes these data, along with a network reference time, into precise three-dimensional position data on the orbits of GPS satellites, plus satellite and ground-station clock offsets. GIPSY OASIS II incorporates the most precise available models of the dynamics of spacecraft, geophysical quantities, propagation of radio signals, and relativistic effects. In addition, it features a modular structure that makes it flexible and adaptable to almost any satellite-tracking estimation problem, plus a unique combination of parameter-estimation techniques that provide capabilities not available together in other software. The demonstrated performance of GIPSY OASIS II is characterized by root-mean-square uncertainties in position of 20 cm for GPS satellites, 5 cm for other satellites, and < 1 cm for ground locations. Timing accuracy better than 1 ns has been demonstrated worldwide, both on the ground and in outer space.

This work was done by William Bertiger, Ron Muellerschoen, Sien-Chong Wu, Yoaz Bar-Sever, Ken Hurst, Geoff Blewitt, Stephen Lichten, Thomas Yunck, Catherine Thornton, James Zumbege, and Michael Hefflin of Caltech for **NASA's Jet Propulsion Laboratory**. For further information, **write in 13** on the TSP Request Card.

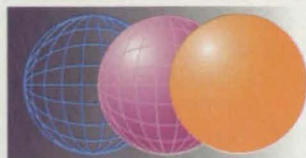
In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-19636, volume and number of this NASA Tech Briefs issue, and the page number.

Improved Software for Predicting Solar Proton Fluxes

An improved version of the Visual Utility for the Localization of Corona Accelerated Nuclei (VULCAN) computer program has been written. The previous version of VULCAN was described in "Predicting Arrival of Protons Emitted in Solar Flares" (NPO-19263), NASA Tech Briefs, Vol. 20, No. 4 (April, 1996), page 50. To recapitulate: VULCAN provides both advance warnings and insight for postevent analyses of the effects of solar flares. Using measurements of the peak fluxes, times of detection, and locations (on the Sun) of radio and x-ray emissions from the Sun, VULCAN predicts the times of



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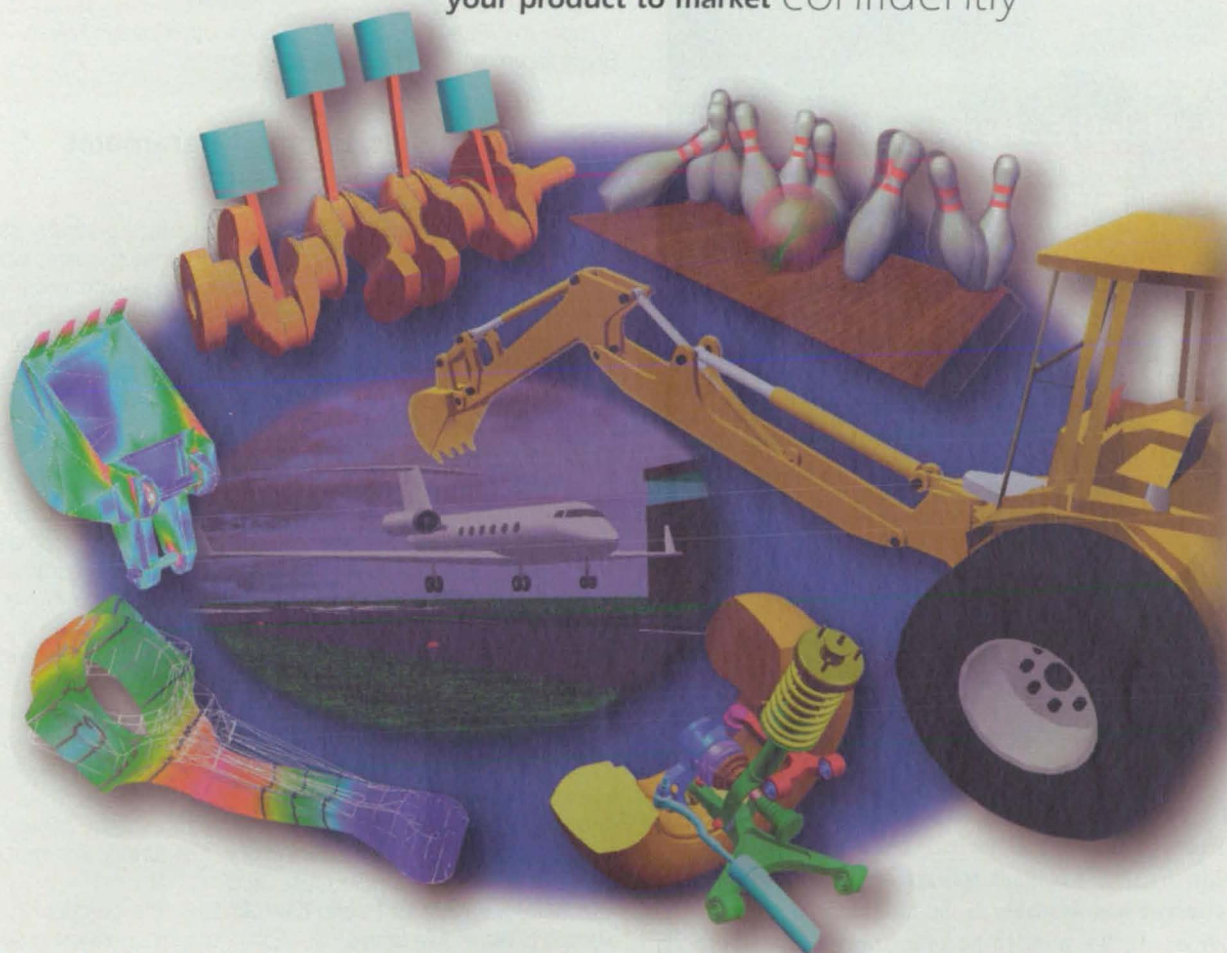
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onset of the fluxes of protons at the Earth, the locations (with respect to the Earth) of incidence of these fluxes, and the peak values of these fluxes. The previous version of VULCAN incorporates a mathematical model of transport of protons along spiral trajectories, the model being presumably valid for Earth. In the improved version of VULCAN, the model of the previous version is extended, so that now it is possible to predict and analyze solar-flare proton fluxes anywhere in the solar system. The improved version also provides additional capabilities for manual entry of solar physical data.

This work was done by John N. Spagnuolo, Jr., Cecilia Cheng, Felipe Hervias, and Ursula Schwuttke of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 26 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-19681, volume and number of this NASA Tech Briefs issue, and the page number.

Software Models Lumped-Parameter Systems in Steady States

The DAGGER computer program simulates the steady-state behavior of a lumped-parameter hydrothermal system, which could contain feedback loops. In comparison with programs developed previously for the same purpose, DAGGER produces the fastest, cheapest, and most accurate simulation. The input to DAGGER comprises a set of algebraic equations and tables that specify the behavior and parameters of the system. Optionally, the input can also include specifications of algorithms representing known feedback loops. The output includes a numerical simulation of the steady state of the system, but DAGGER does not perform the simulation by solving the equations in the "brute-force" manner of other programs. Instead, DAGGER first automatically abstracts a parameter-dependency graph of the model equations in terms of hierarchically nested state and control feedback loops. Then it presents this abstract structure to the user, who specifies preferences for constructing an equation-solving algorithm for each loop. DAGGER thus reduces the space of independent parameters that must be searched and helps the user to compare diverse mathematical models in terms of structural feedback and modeling assumptions.

This program was written by Nicolas Rouquette of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 66 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-19720, volume and number of this NASA Tech Briefs issue, and the page number.



Software for Assessing Ice-Impact Damage in Aircraft Engines

BLASIM is a stand-alone computer code that was developed to assess ice-impact damage on aircraft engine blades. When an aircraft flies through a cloud of supercooled water droplets, ice forms on forward-facing structural components. One such component is the engine inlet. With time, the ice accretes on the inlet and eventually is shed because of vibrations. As a result, blocks of ice traveling at high speed impinge on engine blades rotating at high speed. Impacts of ice can cause severe damage to blades and other parts of the engine. Hence, it is necessary to assess effects of ice impacts.

BLASIM utilizes a computationally efficient coarse mesh of fixed finite triangular plate elements. BLASIM supports mathematical modeling of pressure, temperature, moisture, and centrifugal blade loading. BLASIM performs assessments of local and root impact damage; resonance-margin calculations; and static, dynamic, flutter and fatigue analyses. BLASIM can also perform these assessments and analyses for cases with consecutive ice impacts, with geometry updated after each impact.

BLASIM can model solid, hollow, superhybrid, and composite blades. A solid blade is made of a single material, whereas hollow and superhybrid blades are constructed with prescribed composite materials. A composite blade can have a maximum of seven different material layers with 25 composite plies. The properties of a composite blade can be specified in terms of properties of individual plies or of fiber/matrix combinations.

Geometrical input to BLASIM can be given in either a NASTRAN-type finite-element grid or in airfoil coordinates; this option increases the flexibility of the program. Also, the input to the code can be generated through an interactive program called PREBLASIM, which is provided with the BLASIM package. PREBLASIM cannot be compiled or run on a CRAY computer, but input files can be generated by use of PREBLASIM on another computer and then moved to a CRAY computer. PREBLASIM is not essential to the proper running of BLASIM because the input files can be generated manually.

BLASIM is written in FORTRAN 77.

Three machine versions are available from COSMIC. The CRAY version (LEW-16260) has been successfully implemented on a CRAY Y-MP computer running UNICOS 8.0.3.4, using the CF77 6.0.4.1 compiler. The SGI version (LEW-16259) has been successfully implemented on an SGI Indigo 2 computer running IRIX 5.3, using the FORTRAN 77 4.0.2 compiler. The VAX version (LEW-16140) has been successfully implemented on a DEC VAX-series computer running VMS 5.5, using the FORTRAN 5.4-79 compiler. The standard distribution medium for the CRAY and SGI versions of BLASIM is one 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. The standard distribution medium for the VAX version of BLASIM is one TK50 tape cartridge in DEC VAX BACKUP format. Alternate distribution media and formats are available upon request.

This program was written by E. S. Reddy and G. H. Abumeri of NYMA, Inc., for Lewis Research Center.

For further information on LEW-16140, write in 2 on the TSP Request Card.

For further information on LEW-16259 write in 3 on the TSP Request Card.

For further information on LEW-16260, write in 4 on the TSP Request Card.
LEW-16140/16259/16260

SAGE — Multidimensional Adaptive-Grid Code

The Self Adaptive Grid Code (SAGE) computer program is a flexible software tool for adapting and restructuring two- and three-dimensional computational grids. SAGE can improve the performances of flow-field programs in four ways:

1. The accuracies of the solutions are increased because computational errors are distributed evenly throughout solution domains.
2. Convergence of flow-solver software is accelerated.
3. Flow computations that previously would not converge can now be made to converge.
4. The time and effort needed to create an initial solution grid is reduced, inasmuch as SAGE improves the quality of the grid during the adaptation process.

Solution-adaptive-grid methods are useful for efficient and accurate prediction of flows. In supersonic and hypersonic flows, such strong-gradient regions as shocks, contact discontinuities, and shear layers give rise to the need for careful distribution of grid points to minimize grid errors and produce accurate predictions of flow fields. SAGE helps the

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user obtain solutions of greater accuracy by redistributing (i.e., adapting) the original grid points on the basis of an initial or interim flow-field solution. The user then computes a new solution by submitting the adapted grid as input data for the program being used to solve the equations of flow.

In adaptive-grid methodology, the problem of adaptation of a multidimensional grid is solved by following an algebraic, unidirectional approach. The adaptation procedure is analogous to applying tension and torsion spring forces proportional to the local gradient of flow at every grid point, and finding the equilibrium position of the resulting system of grid points. The adaptation of a multidimensional grid is split into a series of one-dimensional problems along the grid lines. These reduced problems are then solved by use of a tridiagonal algorithm to find the locations of grid points along each coordinate line. The algorithm is applied sequentially in each coordinate direction to achieve the adaptation of the multidimensional grid.

The computed tension forces direct the redistribution of points toward the strong-gradient regions. To maintain smoothness and maximum orthogonality of grid lines, the torsional forces relate information between adjacent families of lines. The smoothness and orthogonality constraints are direction-dependent, inasmuch as these constraints relate the adaptation of each coordinate line only to previously calculated neighboring lines. Therefore, the solutions are nonunique and depend on the order and direction of adaptation solving. The nonuniqueness is acceptable because it makes possible an overall, as well as local, reduction of error via the computed redistribution of the grid.

The ability of SAGE to modify the adaptation in boundary regions substantially increases the flexibility of the adaptive scheme. The vector approach used in the analysis also increases flexibility. The user has complete choice of the direction and order of sequential adaptations, without need to be concerned for the computational data structure. Multiple-pass solutions are available, with no constraints on stepping directions. For each adaptation pass, the user can select a new set of parameters. This capability, combined with edge boundary control, enables the program to individually adapt multidimensional multiple grids. Zonal grids can be adapted while maintaining continuity along common boundaries. For patched grids, the multiple-pass capability enables complete adaptations.

SAGE was written in FORTRAN 77

and is machine-independent. SAGE has been implemented on the following computer/operating system combinations: Sun4/SunOS 4.1.3, SGI Indigo 2/IRIX 5.2, DEC VAX/VMS 5.5, HP 9000 series 700/HP-UX 8.07, CRAY Y-MP/UNICOS, DECstation 3100/RISC ULTRIX 4.3, IBM RS-6000/AIX 3.2, and IBM PC-compatibles/MS-DOS 6.2.

Source code is included with the program, but no sample input and output files are provided. The program reads three data files; a set of original grid coordinates, a set of corresponding flow-field variables, and the user's control parameters. The grid-coordinate and flow-field-variable input files are defaulted to the format defined in the PLOT3D plotting program. PLOT3D is available for several platforms from COSMIC. Computer-memory requirements depend on the size of the grid matrix.

SAGE was developed in 1989, first released in a two-dimensional version in 1992, and upgraded to three dimensions in 1993. The current version (2.0) was released in 1995. SAGE is available in several distribution media and formats from COSMIC (www.cosmic.uga.edu).

This program was written by Carol B. Davies of Sterling Software and Ethiraj Venkatapathy of Thermosciences Institute for Ames Research Center. For further information, write in 36 on the TSP Request Card.
ARC-13359

SINDA/FLUINT Version 2.6

The Systems Improved Numerical Differencing Analyzer (SINDA) computer program is a software system for solving lumped-parameter representations of physical problems governed by diffusion-type equations. SINDA was originally designed for analyzing thermal systems represented in electrical-analog, lumped-parameter form, although its use can be extended to include other classes of physical systems that can be modeled in this form. As a thermal analyzer, SINDA can handle such interrelated phenomena as sublimation, diffuse radiation within enclosures, transport delay effects, and sensitivity analysis.

The Fluid Integrator (FLUINT) program is an advanced one-dimensional fluid-analysis program that solves equations of arbitrary fluid-flow networks. The working fluids can be single-phase vapors, single-phase liquids, or two-phase fluids. The SINDA/FLUINT system enables the analysis of the mutual influences of thermal and fluid problems. While the SINDA/FLUINT software package is often described as two programs, it is

only one whole program and could not be easily separated.

The SINDA system consists of a programming language, a preprocessor, and a subroutine library. The SINDA language is designed for working with lumped-parameter representations and finite-difference solution techniques. The preprocessor accepts programs written in the SINDA language and converts them into standard FORTRAN. The SINDA library consists of a large number of FORTRAN subroutines that perform a variety of commonly needed actions. The use of these subroutines can greatly reduce the programming effort required to solve many problems.

Internally, a complete run of a SINDA/FLUINT model is a four-step process. First, the user's desired model is run through the preprocessor, which writes out data files for the processor to read and translates the user's program code. Second, the translated code is compiled. The third step requires linking the user's code with the processor library. Finally, the processor is executed. SINDA/FLUINT is therefore like an extension of FORTRAN, able to accommodate user instructions and customizations.

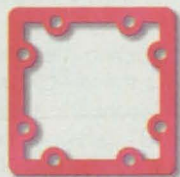
SINDA/FLUINT provides the following capabilities and features: 20,000 nodes, 100,000 conductors, 100 thermal submodels, and 25 fluid submodels. SINDA/FLUINT can model two-phase flow, capillary devices, fluids defined by users, gravity and acceleration body forces on a fluid, and variable volumes. The program enables simulation of nonuniform heating and facilitates modeling of thin-walled heat exchangers. The ability to model nonequilibrium behavior within two-phase volumes is included.

Recently, the following improvements have been added to SINDA: improved automatic timestep control, the ability to model real evaporators, a quick tabular fluid-properties look-up option, the ability to model sonic limits by the detection of choking in all or portions of a model, routines to facilitate the modeling of water hammer and acoustic waves, and higher-fidelity two-phase options including slip flow and flow-regime mapping. Applications range from parametric component sizing to full system-level transient simulation.

SINDA/FLUINT is available by license for a period of ten years to approved licensees. The licensed program product includes the source code and one copy of the supporting documentation. Additional copies of the documentation may be purchased separately at any time.

SINDA/FLUINT is written in FORTRAN 77. COSMIC offers three machine versions of SINDA/FLUINT Version 2.6: one

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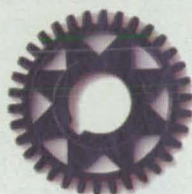
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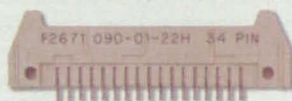
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for DEC VAX-series computers running VMS (MSC-21528), one for CRAY Y-MP-series computers running UNICOS (MSC-21778), and one for HP9000-series 700/800 computers running HP-UX (MSC-22524). COSMIC has also successfully implemented the HP-UX version on DECstation 3100-series computers running DEC RISC ULTRIX and SGI IRIS computers running IRIX. Sample executable codes for each version are provided on the corresponding distribution medium (only HP-UX executable codes are provided for the HP-UX version).

The VAX version of SINDA/FLUINT contains a graphical display program called EXPLOT. EXPLOT requires the DISSPLA graphics software package. The VAX, CRAY, and HP9000 versions of SINDA/FLUINT also contain SINGE, an additional graphics program developed at Johnson Space Flight Center. Both source and executable code are provided for SINGE. If you need to create your own SINGE executable code, you will also need the NASA Device Independent Graphics Library (NASADIG, previously known as SMDDIG; VAX version, MSC-22511; UNIX version, MSC-22512).

The standard distribution medium for the VAX version of SINDA/FLUINT is a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in DEC VAX BACKUP format. It is also available on a TK50 tape cartridge in DEC VAX BACKUP format. The standard distribution medium for the HP9000 version of SINDA/FLUINT is a 4mm DAT tape in UNIX tar format. The standard distribution medium for the CRAY version of SINDA/FLUINT is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. SINDA was originally developed in 1971, with fluid flow added in 1975. A complete rewrite of SINDA occurred in 1985 and the fluid flow for that version was added in 1987. The thermal portions of the old and new versions are very similar, but the fluid-flow parts of the two versions are entirely different. SINDA version 2.6 was released in 1994. Versions of SINDA/FLUINT for the PC, Mac, Sun, and HP are also available from a COSMIC-licensed reseller, as are training, usage support, and a modern graphical user interface that allows analysts to work with SINDA/Fluint models visually.

This program was written by Mark Welch of Lockheed Engineering and Sciences Co. and Brent Cullimore and Steven Ring of formerly Martin Marietta for Johnson Space Center.

For further information on MSC-21528, write in 14 on the TSP Request Card.

For further information on MSC-21778, write in 17 on the TSP Request Card.

For further information on MSC-22524, write in 18 on the TSP Request Card.

MSC-22524

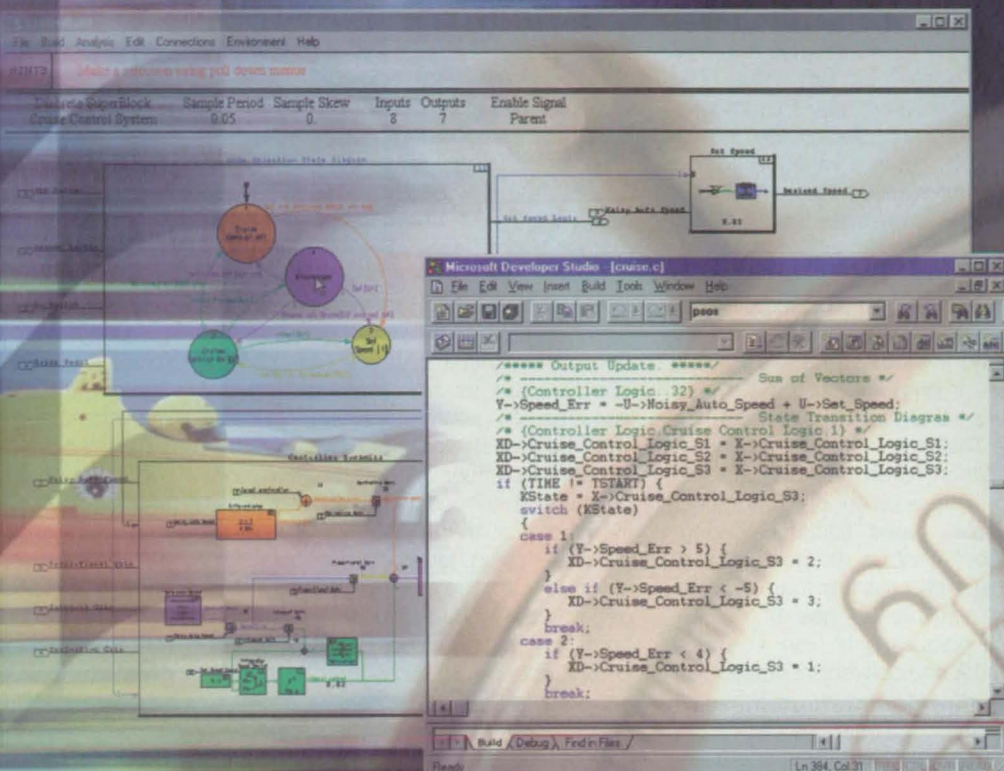


Mathematics and
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Hybrid Automated Reliability Predictor, Version 7.0

The Hybrid Automated Reliability Predictor (HARP) computer program is the modeling engine at the core of Langley Research Center's HiRel software system for prediction of reliability and availability. This program can accept textual input interactively or in the form of input files created by the user, and it produces tabular structured ASCII files as output. Other components of the HiRel suite, which are available separately from COSMIC, provide interactive graphical input/output interfaces for the HARP program. The Graphics Oriented (GO) input program

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enables users to "draw" reliability models of complex systems, using fault-tree notation or Markov graphs. On the basis of these drawings, GO creates files that HARP can accept as input files. The HARP output program, HARPO, enables users to graphically display the tabular HARP output data in a variety of forms. For further information about GO and HARPO, please refer to the COSMIC program abstracts for LAR-15189 and LAR-15190, respectively.

HARP provides a general Markov modeling capability to conveniently model the reliability and availability of a wide variety of systems. Its primary input is in the form of a fault tree that can be entered in textual form. The fault tree is not limited to the traditional combinatorial modeling approach. The addition of four special fault tree gates, called "sequence dependency gates," enables the generation of dynamic fault-tree models that were not practically solvable by use of analytic solution techniques until now. The fault tree, a familiar and convenient notation for expressing reliability models, is automatically converted by HARP into a Markov model, which is solved to produce a reliability prediction. HARP also accepts system reliability and availability models expressed directly in the form of a Markov model, of which the user specifies the origin and destination states, together with a state-transition rate.

For fault-tolerant systems in which redundancy and subsystem reconfiguration are used to achieve ultrahigh predicted reliabilities, even the automatic model-generation capabilities of HARP may be inadequate to cope with the potentially millions of Markov states that would be necessary to model the reliability of a system. HARP offers several innovative model-reduction techniques to make it possible to computationally solve large models. These techniques include model truncation with bounds, state aggregation with fault-tree model generation, use of a simple multifault model, and behavioral decomposition. The simple multifault model is applicable primarily to ultrareliable fault-tolerant system models. Significant state reduction can also be achieved by accurately modeling pairs of nearly coincident faults and approximating the occurrence of more than two nearly coincident faults.

Of all the techniques, behavioral decomposition offers the greatest state reduction when handling of faults and errors is required. Behavioral decomposition is a mathematical technique that exploits two specific behaviors of fault-tolerant systems; (1) failures of hardware parts and subsystems typically occur after thousands of hours of operation

and (2) the time involved in the handling of faults and errors is usually of the order of milliseconds to seconds. The wide disparity — typically six orders of magnitude — of system time constants makes HARP results accurate enough for practical applications. The mathematical basis of behavioral decomposition guarantees that the behavioral-decomposition model will be conservative with respect to the model given to HARP.

HARP can handle (1) dynamic fault trees with repeated nodes (i.e., shared basic events), (2) repairable systems (to determine instantaneous availability) specified by use of Markovian fault-occurrence/repair models, (3) systems with sequence-dependent failures as dynamic fault trees of Markov chains, and (4) systems with cold and warm spares. HARP can utilize the Weibull failure distribution including hot spare repairable systems. It can also provide automatically generated, guaranteed parametric bounds on the reliabilities of systems for a large number of applications of practical interest and for all Markov models.

HARP is written in ANSI FORTRAN 77, and has been successfully implemented by COSMIC on a Sun4 computer running SunOS 4.1.3. Sample Sun4 executable codes are provided on the distribution medium. The authors have also successfully implemented this version on CRAY Y-MP, Alliant, Convex, Encore, Gould, Pyramid, and π Apollo-series computers. If it is necessary to create a new HARP executable code, an ANSI standard FORTRAN 77 compiler will be required. The standard distribution medium for the Sun version of HARP is a 0.25-in. (6.35-mm) streaming-magnetic tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. HARP has been under development since 1981, and HARP v7.0 was released to COSMIC in 1994.

This program was written by S. J. Bavuso of Langley Research Center and E. Rothmann, and J. B. Dugan of Duke University. For further information, write in 38 on the TSP Request Card. LAR-15188

Software for Graphical Input to HARP

The Graphics Oriented (GO) computer program is one component of Langley Research Center's HiRel software system for prediction of reliability and availability. GO provides an interactive, graphical interface for producing input to the Hybrid Automated Reliability Predictor (HARP) computer program. HARP, which is available separately from COSMIC (see

LAR-15188), is the modeling engine at the core of HiRel. A third component, HARPO (see LAR-15190), serves as a graphical postprocessor for HARP.

Often, a reliability engineer must graphically represent a reliability model before it can be solved. The graphical-input capabilities of GO increase productivity and decrease the incidence of error. In addition to aiding in the verification of the reliability model, GO provides reliability engineers with a readily understandable format for presenting complex model information to company management, regulatory agencies, and company customers.

With GO, a user can interactively describe a reliability system as either a fault tree or as a Markov chain. Fault-tree representations are easily described, and HARP can convert them into Markov-chain systems before solving them. Fault trees are readily understandable as initial models for reliability systems; however, they are unable to model systems with repairs, so the Markov-chain conversion can be used thereafter to complete the model by adding repair transitions and rates.

Graphical-user-interface (GUI) software tools and primitives provided by GO to model Markov chains include circles to represent system states or nodes, arrows to connect states in Markov chains, and arcs for state transitions or repairable systems. GO also includes many flexible software tools and graphical primitives for modeling fault trees. A failure box is used to represent a failure of a system. Circles are provided for basic failure events in a tree. For logical operations, OR gates, AND gates, and M/N gates (at least M out of N events must occur to make such a gate produce an output) are provided.

GO also supplies a number of more complex logical gates. The introduction of dependency gates in fault-tree notation enables the modeling of very large fault-tolerant systems by use of a concise, visually recognizable, and familiar graphical language. Functional dependency gates, each of which can take one "trigger" input and produce one or more dependent outputs and a normal output, can be used in fault-tree diagrams. When a trigger event occurs, the dependent events are forced to occur, while the normal output reflects the status of the trigger event. Priority-AND gates are also available when designing fault trees. In a priority-AND gate, both input events must occur, and the events must occur in certain order. Finally, GO includes a cold-spares gate that produces output when all of the inputs have occurred.

GO is written in C language for Sun4-series computers running SunOS 4.1.3, SunGKS 4.1 (Sun Microsystems, Inc.

Graphics Kernel System), and either Sun Microsystems' Openwindows or revision 5 of version 11 of MIT's X Window System. Because the GKS run-time libraries are supplied with HARPO, it is not necessary to purchase GKS for execution. A sample executable code is provided on the distribution medium. If it is necessary to create a new executable code, then the Sun C compiler and the GKS INCLUDE files, which are not supplied, will also be needed. Recompilation should not be necessary on Sun4 computers. The standard distribution medium for the Sun version of GO is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. GO has been under development since 1985 and was released to COSMIC in 1993.

This program was written by S. J. Bavuso of Langley Research Center, and E. Rothmann, and N. Mittal of Duke University. For further information, write in 39 on the TSP Request Card.
LAR-15189

Program Plots HARP Output

The Hybrid Automated Reliability Predictor Output Graphics Display (HARPO) computer program interactive-

ly plots output data from the HARP computer program (see LAR-15188) and supplies design engineers with a powerful software tool for displaying alternate model data for tradeoff analyses. HARPO provides a clean, simple set of interactive prompts and menus in a graphical display environment. With this software, the following types of analyses can be performed: unreliability vs. mission time, probability-of-failure bounds, worst/best-case bounds, summation of state probabilities, and sensitivity of systems failure.

HARPO was designed to be more than a graphical-display program for HARP. HARPO provides a means of analyzing the huge amounts of tabular reliability data produced by HARP, thus enabling the user to make tradeoffs between design alternatives within a particular system architecture or to compare different system architectural alternatives simultaneously. Although this program can be used without an in-depth knowledge of the capabilities of HARP, a correct interpretation of the meaning of the graphical data does require that knowledge. Users of HARPO are encouraged to obtain the HARPO documentation.

HARPO is written in ANSI FORTRAN

77 for Sun4-series computers running SunOS 4.1.3, SunGKS 4.1 (Sun Microsystems, Inc. Graphics Kernel System) with the Sun GKS FORTRAN binding and either Sun Microsystems' Openwindows or revision 5 of version 11 of MIT's X Window System. Because the GKS run-time libraries are supplied with HARPO, it is not necessary to purchase GKS for execution. A sample executable code is provided on the distribution medium. If it is necessary to create a new executable code, then the Sun FORTRAN 77 compiler and the GKS INCLUDE files, which are not supplied, will be needed. Recompilation should not be necessary on Sun4 computers. The standard distribution medium for HARPO is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in (Sun QIC-24) in UNIX tar format. HARPO has been under development since 1985 and was released to COSMIC in 1993.

This program was written by S. J. Bavuso of Langley Research Center, D. W. Sproles of Computer Sciences Corp., and T. R. Arthur of the Volunteer Services Program of Old Dominion University. For further information, write in 40 on the TSP Request Card.
LAR-15190

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Clutch Combined With Screw-Released Roller Brake

Sprags are jammed and unjammed to effect braking and release, respectively.

Goddard Space Flight Center, Greenbelt, Maryland

Several improved brake/clutch mechanisms related to both overrunning clutches and roller locking devices have been invented. Braking in these mechanisms is effected by roller locking sprags, which are well known in brake and clutch engineering: Roller locking sprags are partly symmetrical or asymmetrical (in all three dimensions) devices or bodies with convex, curved outer wedge surfaces that make contact with concave and convex, curved wedge surfaces of relatively rotating members. The wedge surfaces of the sprags are jammed between the wedge surfaces of the relatively rotating members to stop the relative rotation, or are unjammed to allow relative rotation.

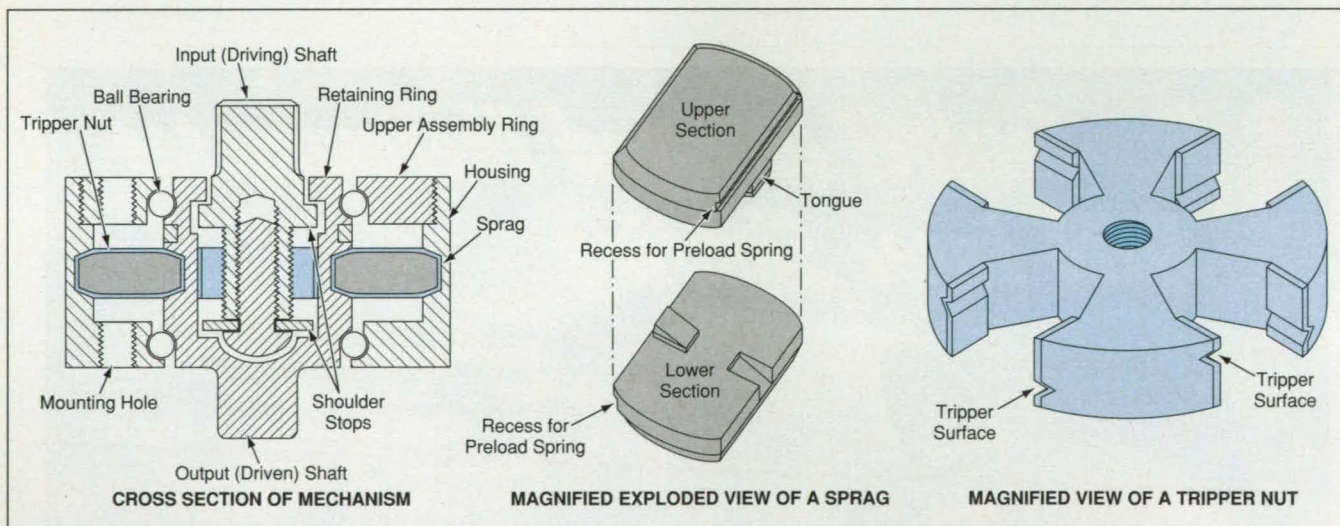
shaft is rotated to drive the output shaft.

During normal operation with the input shaft stationary, any attempt to rotate the output shaft causes the sprags to become jammed between a groove with wedge surfaces on the output shaft and a groove with wedge surfaces in the housing. This jamming prevents the output shaft from rotating with respect to the stationary housing; in other words, the output shaft becomes braked.

Each sprag comprises an upper section and a lower section that mate with each other through tongues and grooves with wedge surfaces. Preload springs bias the upper and lower sec-

the tripper nut rides up or down on the thread until its tripper surfaces engage mating surfaces on the sprags, pushing the upper and lower sections of the sprags together and thereby releasing the brake.

With continued rotation of the input shaft, the tripper nut is driven up or down against one of two shoulder stops on the input shaft. Thereafter, rotation of the input shaft is coupled to the tripper nut, then through the tripper nut and splines to the output shaft, so that the mechanism acts as an engaged clutch. Rotating the shaft by the appropriate amount in the opposite direction disengages the clutch and restores the brake.



In this **Brake/Clutch Mechanism**, braking or release of the output shaft is effected through rotation of the input shaft to jam or unjam roller locking sprags. Beyond the point of unjamming, rotation of the input shaft is coupled to the output shaft.

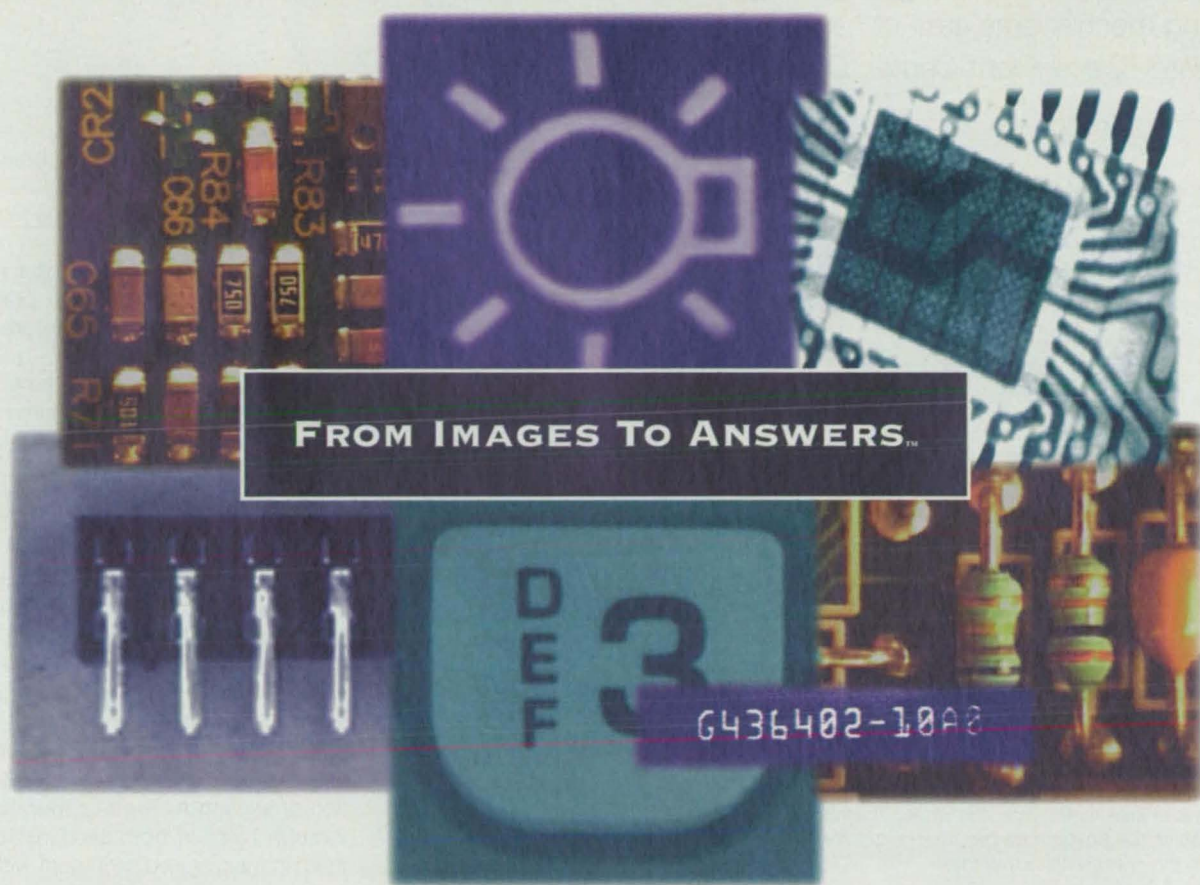
The mechanisms are rather complicated, and it is possible to describe only a few salient aspects of one of them in this article. The mechanism (see figure) is connected to an input shaft (which can be actuated by a motor and gears) and an output shaft (which can be connected to a rotary load). The mechanism includes a housing that is bolted to a stationary structure. The overall function of the mechanism is to brake the output shaft against rotation except when the input

tions along the tongue and groove surfaces in a direction to push the outer convex wedge surfaces into contact with the wedge surfaces of the grooves on the output shaft and in the housing.

The sprags can be unjammed by pushing the upper and lower sections together. For this purpose, the mechanism includes a tripper nut that is threaded onto the input shaft and that mates with the output shaft via loosely fitting splines. When the input shaft is turned clockwise or counterclockwise,

This work was done by John M. Vranish of Goddard Space Flight Center. For further information, write in 57 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13674.



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Roller Unlocking Sprags

Tripping mechanisms are not necessary for unlocking.
Goddard Space Flight Center, Greenbelt, Maryland

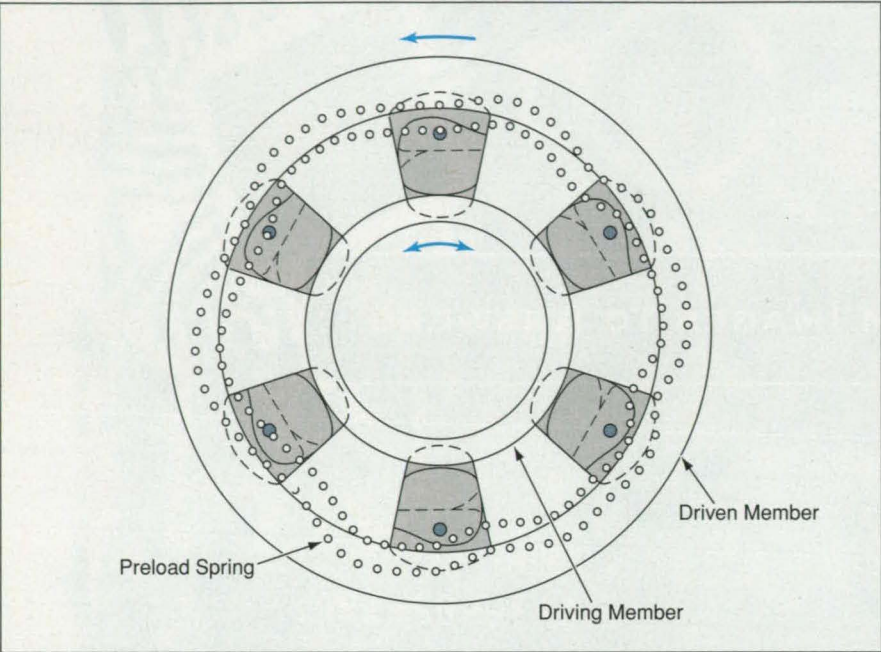


Figure 1. The **Sprags Roll Into Lock** when an attempt is made to turn the driving member counterclockwise faster than the driven member rotates. When the driving member rotates clockwise or the driven member rotates counterclockwise faster than does the driving member, then the sprags roll out of lock.

Improved roller locking sprags have been invented for use in brake and clutch mechanisms — especially one-way, overrunning clutches (see Figure 1). In their locking action, these sprags function similarly to other roller locking sprags, as described in the preceding article. However, unlike other roller locking sprags, these can be unlocked under load without using tripping mechanisms that force the sprags into sliding motions to overcome locking friction; instead, these sprags can be unlocked under load with a rolling motion in the direction opposite that of the rolling motion that causes them to lock.

Each sprag of the present type includes two roller sprag sections, denoted A and B in Figure 2, with chamfered surfaces that make contact with relatively rotating members like the shaft and housing of Figure 1. Along with a preload spring, the tanglike portion of section B is inserted in the clevislike portion of section A. A pin is then inserted through holes in both sections to keep them in the required alignment with each

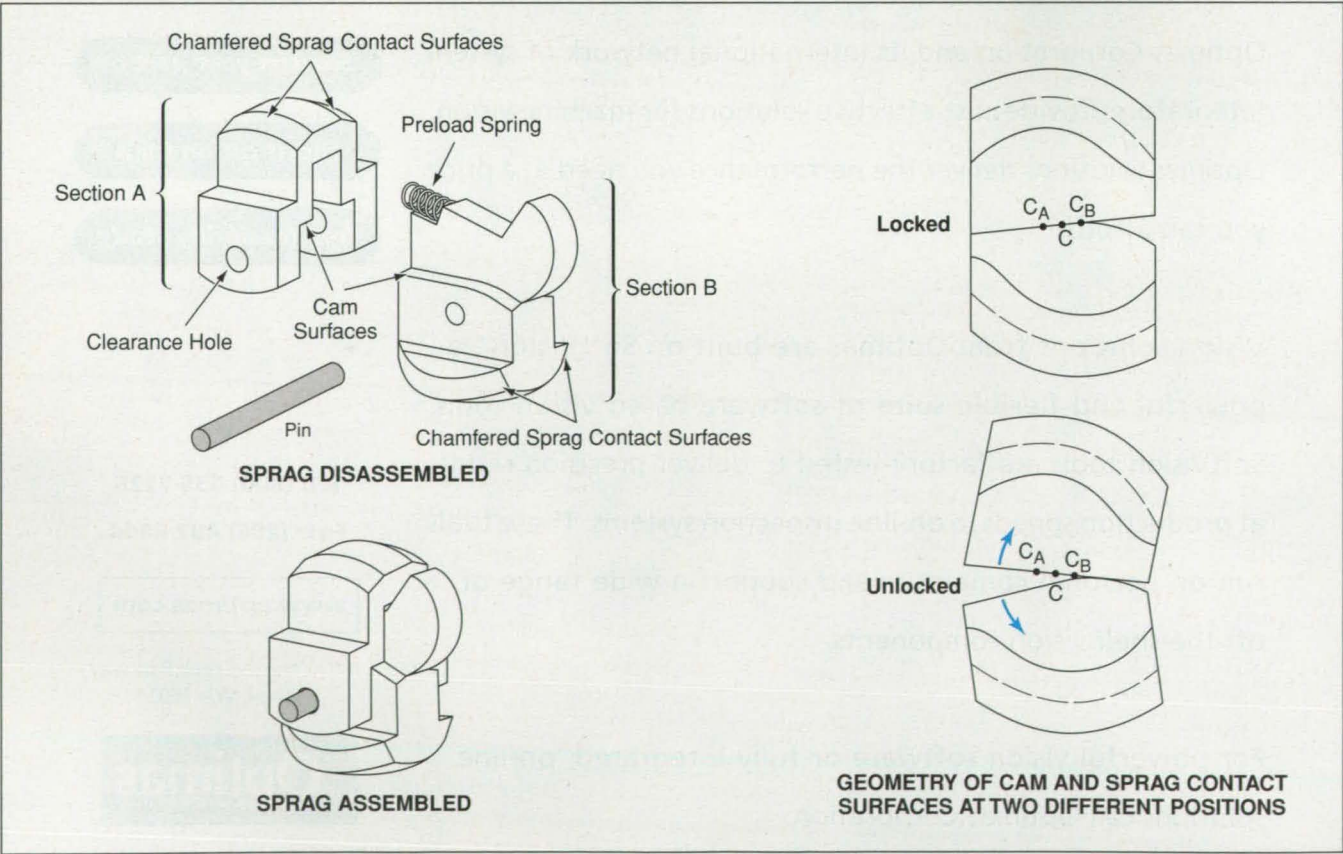
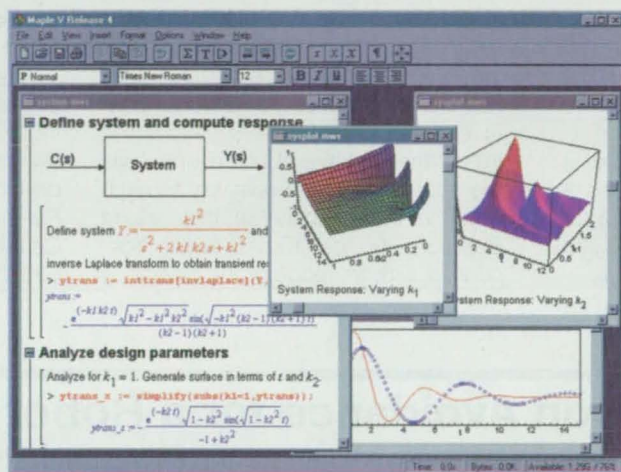


Figure 2. A **Roller Unlocking Sprag** features three-dimensional rolling surfaces shaped to provide a roller unlocking motion while the sprag is still under load.

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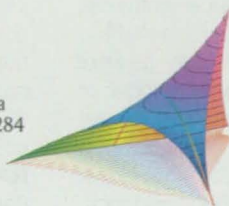
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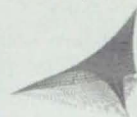
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other. The pin fits snugly in the hole in section A, but the holes in section B are somewhat wider to give a large clearance around the pin.

In operation, the loads on the chamfered sprag contact surfaces push sections A and B toward each other, causing them to make rolling contact with each other at some point along mating cam surfaces. As shown in Figure 2, these cam surfaces are slanted, the cam surfaces on section A are straight, and the cam surfaces on section B are curved. The slant and curvature of the cam surfaces and the clearance around the pin are chosen to provide three centers of rotation at different positions along the cam surfaces; a center C for rotation of the sprag as a whole, a center C_A (to the left of C) for rotation of section A, and a center C_B (to the right of C) for rotation of section B.

The limitation on space available for this article precludes a detailed description of (1) the complex geometric relationships that involve the centers of rotation and the sprag contact surfaces, and (2) the effects of these relationships on the resolution of forces. The net effects of these relationships can be summarized as follows:

- As torque builds up during locking under a large load, the pin is pushed hard against the clearance hole in section A, and sections A and B are thereby constrained to move together as a unit, behaving similarly to a conventional roller locking sprag.
- When the two members coupled via the sprag are turned relatively to each other in the opposite of the locking direction, the pin moves away from contact with the edge of the clearance

holes in section A. Within the clearance thus provided, sections A and B are free to rotate in opposite directions about C_B . This rotation causes shortening of the line between the contacts of the chamfered sprag contact surfaces and the contact surfaces of the relatively rotating members; in other words, the sprag rolls out of lock.

This work was done by John M. Vranish of Goddard Space Flight Center. For further information, write in 56 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13692.

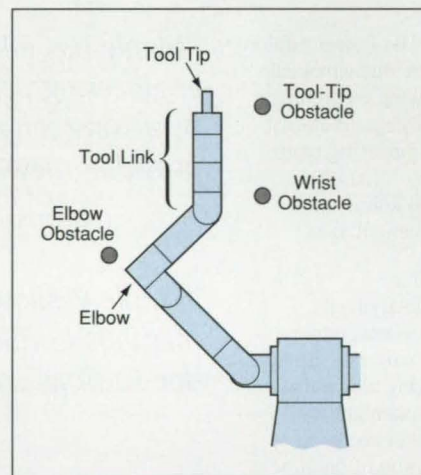
Real-Time Collision Avoidance for a Robot Arm

Obstacles are modeled as though they were repelled by springs with dampers.

NASA's Jet Propulsion Laboratory, Pasadena, California

Software undergoing development for use in controlling an experimental robot arm includes algorithms that process data computed by obstacle-detection software to generate commands for perturbing the trajectory of the arm away from the commanded trajectory whenever the commanded trajectory brings the arm within a specified standoff distance from one or more obstacle(s). [The obstacle-detection software used in conjunction with this collision-avoidance software is described in the following article, "Real-Time, Model-Based Obstacle Detection for a Robot Arm" (NPO-19862).] The collision-avoidance software is designed to provide real-time collision avoidance while maintaining the stability of the robot-control system. The software is based on the configuration-control concept, which has been discussed in numerous prior articles in *NASA Tech Briefs*.

The robot arm comprises three links and seven joints. For purposes of detecting obstacles and avoiding collisions with them, the arm is divided into a tool-tip zone, a wrist zone, and an elbow zone. An obstacle for which the nearest point on the arm is on the tool link and is closer than a specified threshold distance from the tool tip is designated a tool-tip obstacle. An obstacle for which the nearest point on the arm is on the tool link but farther than the specified threshold distance from the tool tip is designated a wrist obstacle. An obstacle for which the



The Robot Arm Avoids Up to Three Obstacles according to control algorithms that alter the trajectory of the arm as though springs and dampers pushed the arm away from obstacles that it approached too closely.

nearest point on the arm is on the upper or lower arm link is designated an elbow obstacle (see figure).

In the collision-avoidance software, each zone of the robot arm is mathematically modeled as though it were equipped with a spring and damper to prevent a hard collision with the nearest obstacle. Whenever an obstacle in a given zone approaches the arm closer than a user-specified standoff distance, as computed by the obstacle-detection software, the collision-avoidance soft-

ware computes a repulsive virtual force proportional to the incursion of the obstacle. The collision-avoidance software also computes a damping force proportional to the approaching velocity of the arm and the obstacle. The trajectory of the arm is then perturbed from the commanded trajectory by the computed spring and damping forces to prevent a collision with the obstacle.

Tool-tip virtual forces perturb the position of the tool tip. Wrist virtual forces perturb the orientation of the tool link. Elbow virtual forces perturb the arm angle. The three-zone arrangement makes it possible to limit the perturbation computations to no more than three obstacles at a time. A single point obstacle near the tool link perturbs either the position or the orientation of the tool tip, depending on its distance from the tool tip. An extended obstacle could be detected as two point obstacles — one in the tool-tip zone and one in the wrist zone, thus perturbing both position and orientation. These collision-avoidance policies are adopted for simplicity of concept, ease of implementation, and minimization of the computational burden while providing robust control performance.

This work was done by Bruce Bon and Homayoun Seraji of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 65 on the TSP Request Card. NPO-19861

Real-Time, Model-Based Obstacle Detection for a Robot Arm

Procedural shortcuts and simplified geometrical models make for computational speed.

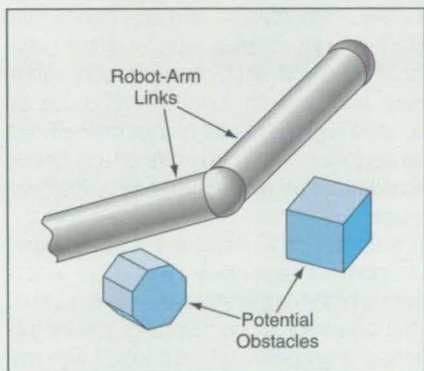
NASA's Jet Propulsion Laboratory, Pasadena, California

Software that implements model-based detection of obstacles in real time has been developed for use in conjunction with the software described in the preceding article, "Real-Time Collision Avoidance for a Robot Arm" (NPO-19861). The obstacle-detection subsystem of a robot can be either (1) sensor-based in that it utilizes proximity sensors or machine vision to identify obstacles or else (2) model-based in that it identifies obstacles via mathematical models, using geometric computations on a data base that includes locations and geometries for robotic-manipulator arms and all potential obstacles. Heretofore, model-based obstacle detection has been used mostly in non-real-time simulation and planning software, and has thus not been required to function in real time. In the specific application for which this model-based obstacle-detection software was developed, the robot is not

arm links). Each link is represented as a round cylinder with hemispherical end caps, and other obstacles are represented as polyhedrons (see figure). Positions and orientations of the links are computed from the forward kinematics of the robot arm, using the known joint angles. Distances between the nearest points on these geometric constructs are computed straightforwardly from the equation

for the distance between a line and a face and the equation for the distance between two lines.

Another important element of the minimalist approach is the use of prioritized lists of potential obstacles to eliminate needless computations of distances while ensuring that the distances between robot-arm links and the most likely obstacles are computed, even



Simple Geometric Models can be represented by simple equations, providing for rapid computation of approximate distances of closest approach between robot-arm links and potential obstacles.

equipped with sensors for detecting obstacles in real time; the software is required to act as a suite of virtual sensors on the robot arm and compute the proximity of obstacles. In other words, the software must furnish essentially the same real-time proximity data that sensors would furnish.

To achieve the speed needed for real-time performance, it is necessary to minimize the computational burden, and this, in turn, necessitates a minimalist approach to the mathematical modeling of obstacles. An important element of the minimalist approach is the use of simple geometric models to represent potential obstacles to each robot-arm link (obstacles can include other robot-

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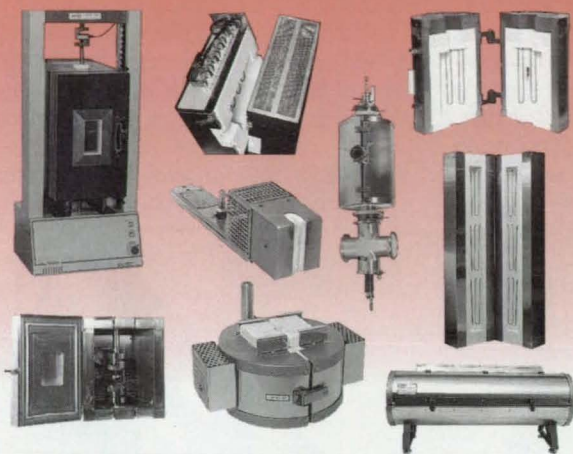
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when the computation must be terminated early to satisfy the real-time requirement. The prioritized list is based partly on real-time data on the position and orientation of each link; at any given time, most of the objects in the workspace of the robot are out of the potential reach space of a given link and are therefore excluded from the distance computations.

This work was done by Bruce Bon and Homayoun Seraji of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 64 on the TSP Request Card. NPO-19862

Dynamic Face Seal for a Wide Range of Conditions

The seal automatically accommodates thermal expansion and wear.

Lewis Research Center, Cleveland, Ohio

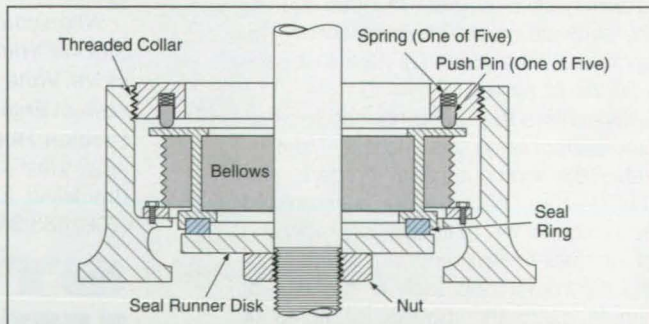
A dynamic face seal has been designed to provide adequate sealing against gas for a shaft that rotates in an oxidizing, inert, or reducing atmosphere (e.g., air, argon, or hydrogen, respectively). The seal is also designed to function at all temperatures from somewhat less than 25 °C to somewhat more than 900 °C, by suitable choice of seal materials and by incorporation of sprung parts that automatically adjust themselves to compensate for thermal expansion (or contraction) and wear.

The seal (see figure) includes a stationary seal ring made of a self-lubricating material called "PM212" — a metal composite made from powders of chromium carbide with a nickel-base binder (70 percent) combined with silver (15 percent) and with a eutectic mixture of barium and calcium fluorides (15 percent). The seal ring is spring-loaded against a seal runner disk affixed to the rotating shaft. The seal runner disk is made of a superalloy to withstand high temperature. A welded superalloy bellows prevents secondary leakage.

The spring preload is adjustable by use of a threaded collar. The preload springs act upon five superalloy push pins, which slide in chambers filled with a high-temperature-resistant grease; the sliding of the pins in the grease provides damping. Initially, the collar is adjusted until the seal ring comes in light contact with the seal runner disk. Thereafter, spring deflection automatically compensates for thermal expansion (or contraction) and wear.

This work was done by Christopher DellaCorte of Lewis Research Center. For further information, write in 30 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-15870.

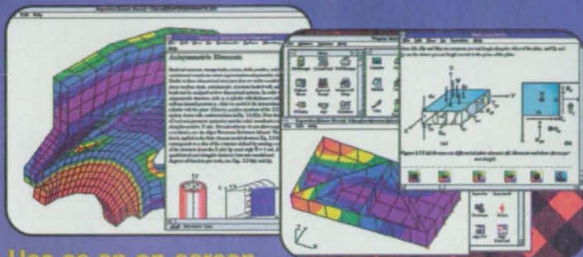


This Dynamic Face Seal tolerates a wider range of conditions than do other seals like carbon face, noncontact labyrinth, and ferrofluid seals.

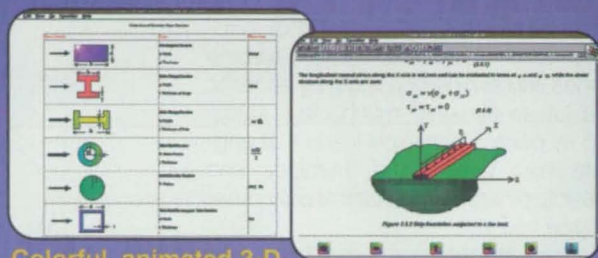
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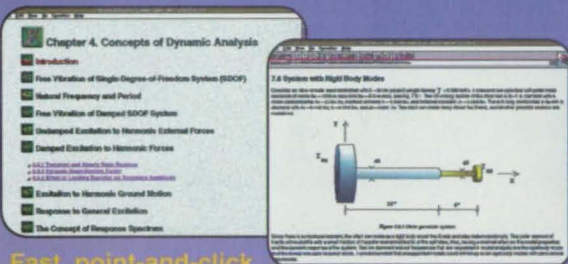
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Dr. Constantine Spyrakos is a Professor in the College of Engineering at West Virginia University. He holds B.S. and M.S. degrees in Civil Engineering from the Technical University of Athens, Greece. He also holds an M.S. in Engineering Mechanics and a Ph. D. from the University of Minnesota. Dr. Spyrakos is widely considered a leading authority in computational mechanics methods.



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FEM/BEM Analysis of Fatigue in Aeropropulsion Structures

Acoustic and other dynamic loads, moisture, and temperature are all taken into account.

Lewis Research Center, Cleveland, Ohio

A method of computing dynamic stresses and strains and the resulting fatigue in composite-material structures involves the use of the normal-mode method to obtain the basic dynamical equations, plus solution techniques from the finite-element method (FEM), the boundary-element method (BEM), and a combination FEM/BEM. The method is applicable to a variety of problems; it was developed to be particularly useful in predicting the fatigue degradation of aeropropulsion structures (e.g., turbine blades and engine housings) by acoustic and other dynamic mechanical loads, and by partly mechanical loads that originate from temperature, humidity, and possibly other nonmechanical phenomena (see figure).

In the normal-mode method, one seeks the solution of a nonhomogeneous differential equation with homogeneous boundary conditions. Such an equation and boundary conditions are usually applicable in the case of a beam, plate, or shell, and heretofore, the normal-mode method has been known as the most powerful method of analysis of vibrations in beams, plates, and shells. The external forces (from acoustic pressures and other sources of vibrations) in such cases appear in the nonhomogeneous terms of the equations of motion and are treated as body forces.

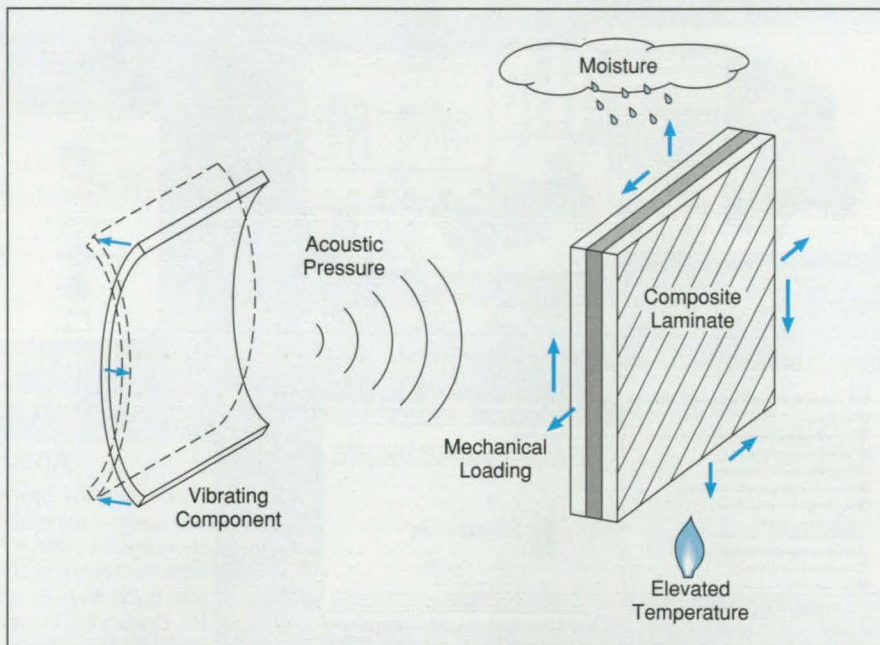
In the case of a two-dimensional (plane-strain) or three-dimensional vibration problem, the boundary conditions are time-dependent rather than homogeneous, but the differential equation of motion is homogeneous. Thus, the normal-mode method cannot be used directly in this case. Solutions of boundary-value problems with time-dependent boundary conditions can be obtained by Laplace, Fourier, and other integral-transform methods, but these methods lack the advantages of the normal-mode method for analysis of vibrations.

Accordingly, one innovative aspect of the present method is a provision for transforming a differential equation of two- or three-dimensional motion with time-dependent boundary conditions into a nonhomogeneous differential equation with homogeneous boundary conditions, so that the normal-mode method can then be applied. A second innovative aspect of the present method is the adoption of the BEM for analysis of anisotropic structures under dynamic

loads, which can include thermal and hygral effects. The great challenge in applying the BEM to such a problem is to obtain the particular solution of equation of motion. In the present method, this is accomplished by use of second-

fatigue in the structure. In this analysis, acoustic fatigue, durability, and lifetime are assessed in terms of a margin of safety with a first-ply-failure criterion.

The BEM and FEM versions of the present method were tested in compar-



Effects of Severe Loads and Environmental Conditions are taken into account in the present method, which incorporates techniques from the normal-mode, finite-element, and boundary-element methods into a computationally efficient means for analyzing fatigue in composite-material structures.

order polynomial functions to express displacement and traction. A third innovative aspect is a methodology of fatigue analysis and prediction of degradation in composite-material structures, as described next.

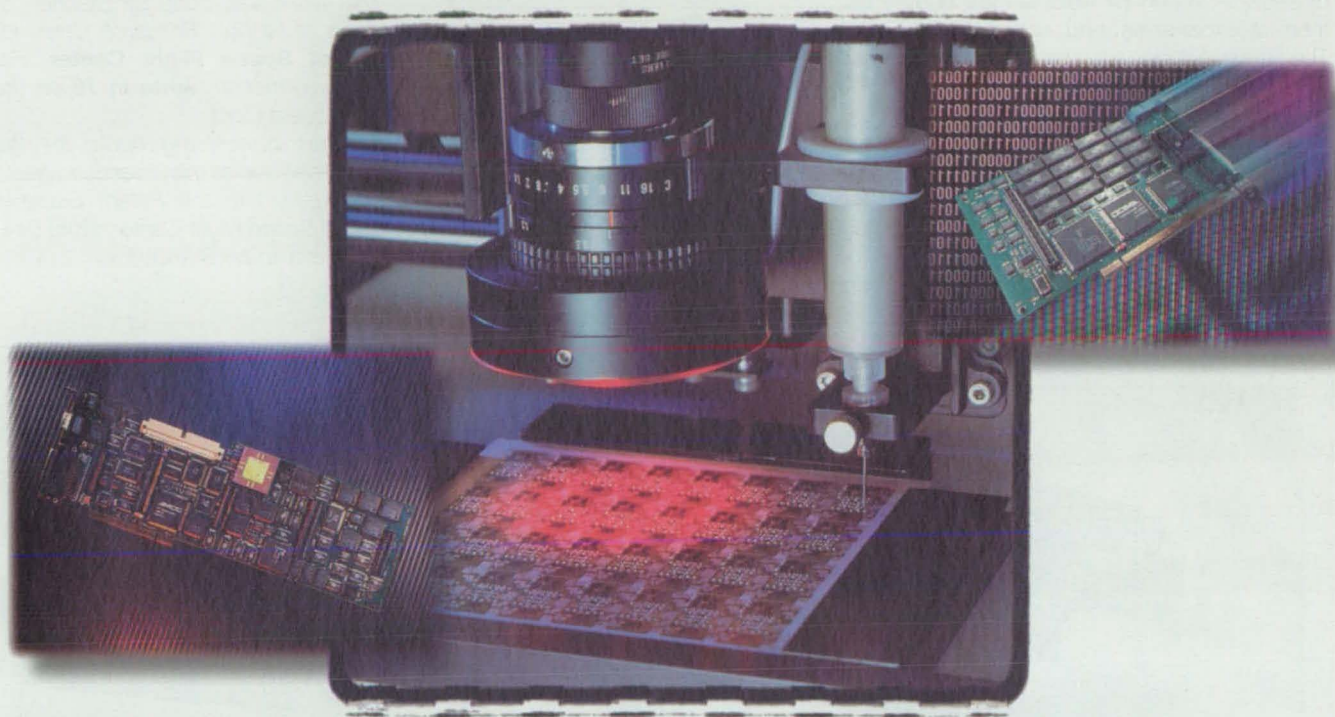
A complete modal description of a structure includes the modal (also called the "natural") vibrational frequencies, the modal shapes, and the modal damping parameters. The modal frequencies and shapes can be obtained by solving the free-vibration problem, using the BEM, FEM, and FEM/BEM methods. Then the modal response to acoustic pressure (which is assumed known) can be obtained by solving the corresponding forced-vibration problem. Next, the complete distribution and history of stresses in the structure can be assembled from the solution of the forced-vibration problem, using source terms obtained from spectral analysis of input acoustic sources. The resulting information on stresses is then used for the analysis and prediction of acoustic

ison with each other and with the FEM/BEM by applying them to a two-dimensional approximation of the vibration problem of a laminated cantilever plate. The BEM, FEM/BEM, and FEM all yielded similar natural frequencies for the first five modes of vibration. However, relative to the FEM, the computation times for the BEM/FEM and for the BEM were only 0.39 and 0.09 times as long, respectively. The reductions of computation time for three-dimensional problems are expected to be even more pronounced.

This work was done by Z. Li and Seng C. Tan of Wright Materials Research Co. for Lewis Research Center. For further information, write in 95 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16071.

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Gauge Measures Mismatch and Peaking at Welds

This tool provides two independent measurements simultaneously.

Marshall Space Flight Center, Alabama

A simple, hand-held, rugged, easy-to-use gauge provides measurements of mismatch and peaking at a weld joint between two flat bars, plates, or similar workpieces. "Mismatch" and "peaking" denote the translational and angular misalignments between the two workpieces (see Figure 1). These misalignments are attributable mostly to a combination of imperfect weld setups and thermal expansions and contractions. The gauge includes a left part and a right part that translate with respect to each other to indicate mismatch, and rotate with respect to each other to indicate peaking.

Figure 2 shows the use of the gauge at a weld joint between two bars. First, the gauge is positioned approximately astride the weld joint (but not yet touch-

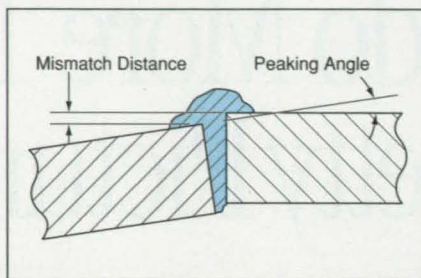


Figure 1. **Mismatch and Peaking** are the principal measures of misalignment between welded workpieces.

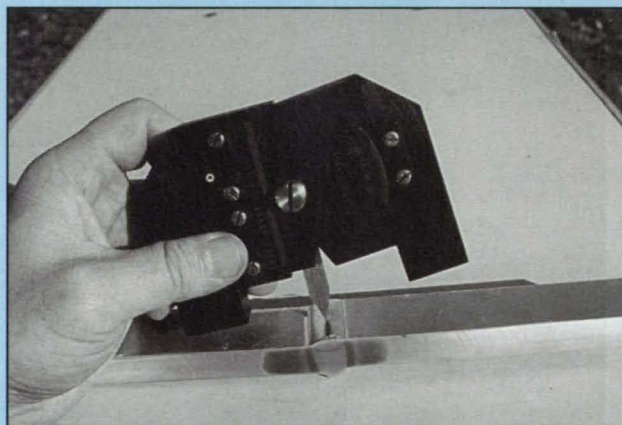
ing the bars). The pointer is placed on the centerline of the weld bead. Next, the left part of the gauge is pressed flat against the left bar. Then the right part of the gauge is pressed flat against the right bar. The mismatch distance and

peaking angle can then be read from scales and index marks on the gauge.

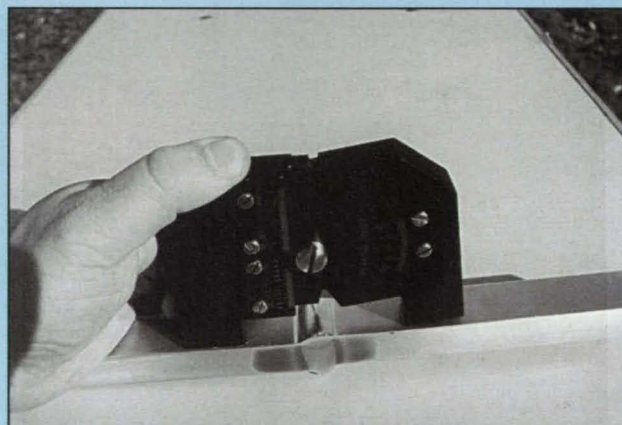
The gauge can indicate mismatch to the nearest 0.01 in. (0.25 mm) and peaking to the nearest half degree. With the addition of a scale and index mark to the center-line pointer, the gauge could be made to indicate the height of the weld bead.

This work was done by Stephen S. Gordon of Nichols Research Corp. for Marshall Space Flight Center. For further information, write in 76 on the TSP Request Card.

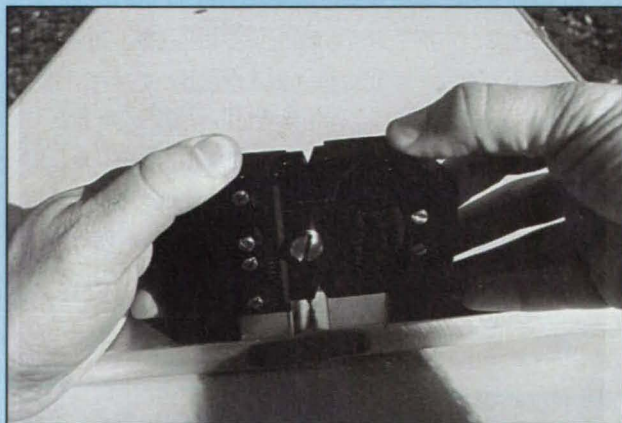
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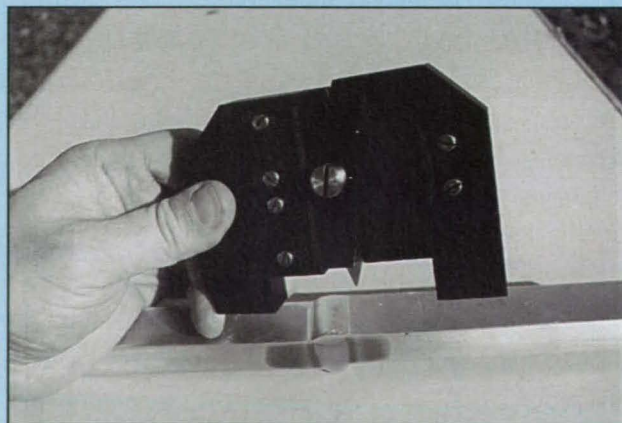
Step 1: Extend centerline pointer and place on centerline of weld.



Step 2: Push left part of gauge down flat against left bar.

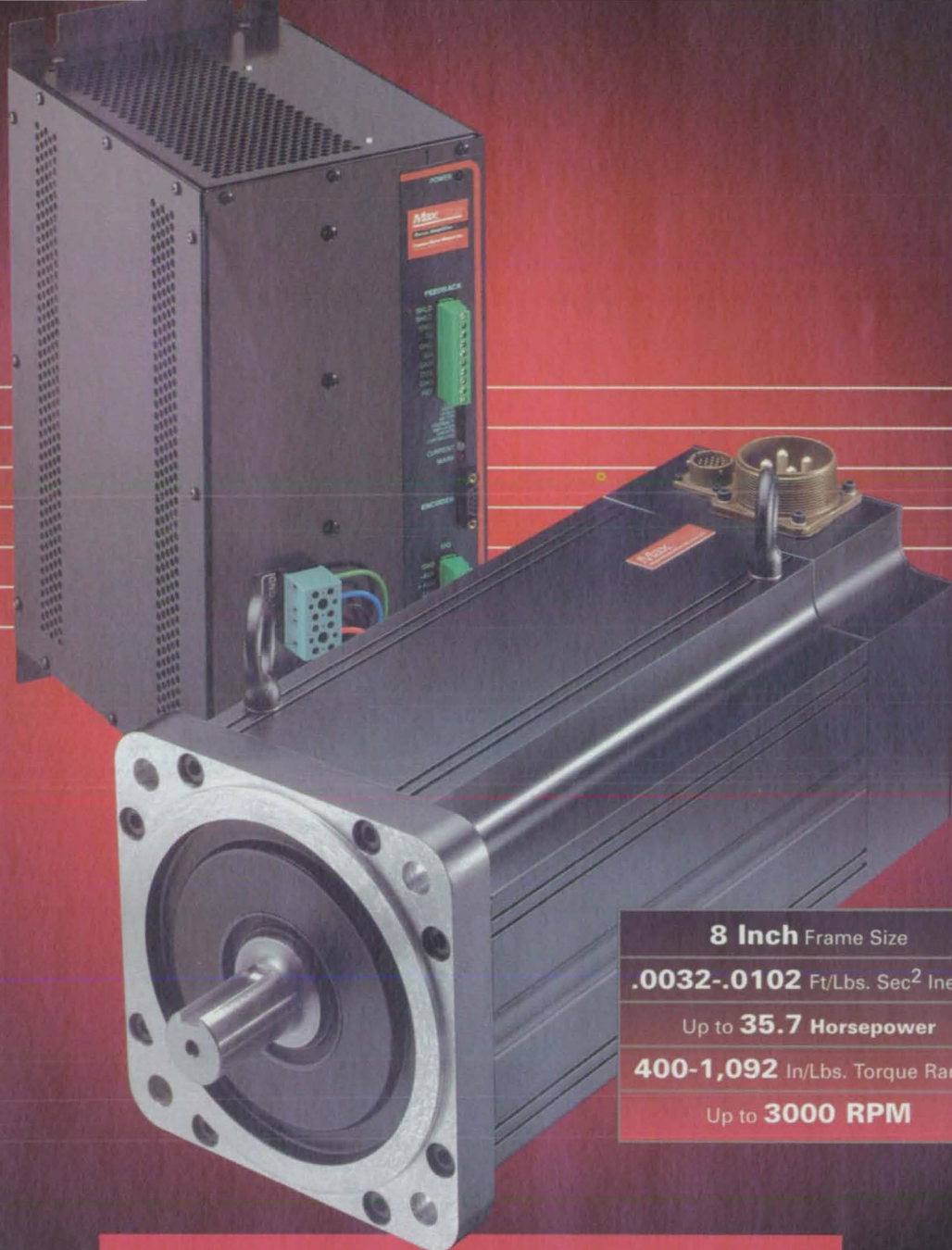


Step 3: Push right part of gauge down flat against right bar.



Step 4: Read the mismatch and peaking measurements.

Figure 2. The **Gauge Is Used** to measure mismatch and peaking between two bars. The measuring surfaces of the gauge are pressed against the bars to align the gauge with the bars.



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Machine for Polishing Nearly Cylindrical Mirror Mandrels

Numerical control would provide greater consistency.

Marshall Space Flight Center, Alabama

A numerically controlled machine for polishing precise mirror surfaces on cylindrical and nearly cylindrical axisymmetric mandrels is undergoing development. The machine is intended to serve as a test bed for further development of techniques and materials for polishing mirror surfaces for astronomical x-ray telescopes.

Numerically controlled machines for polishing flat, spherical, and nearly spherical mirror surfaces are available, but until now, there has been no such machine for polishing cylindrical and nearly cylindrical surfaces. As a result, cylindrical and nearly cylindrical mandrel surfaces have been polished by spinning the mandrels while manually holding polishing pads in contact with the surfaces. Such manual polishing is relatively

expensive because it entails constant attention by technicians and only one technician can work on one mandrel at a time. Manual polishing is also limited by technicians' fatigue, and there are variations among the surface finishes achieved by different technicians. The semiautomated operation of the developmental polishing machine will overcome the disadvantages of manual polishing, eliminating both the need for constant attention by technicians and the personal variations in surface finishes.

The machine (see figure) includes an air-bearing table that suppresses vibrations of external origin. A base plate mounted on the air-bearing table supports a motor drive that spins the mandrel about its axis of symmetry at a speed of 30 r/min. In the Cartesian coor-

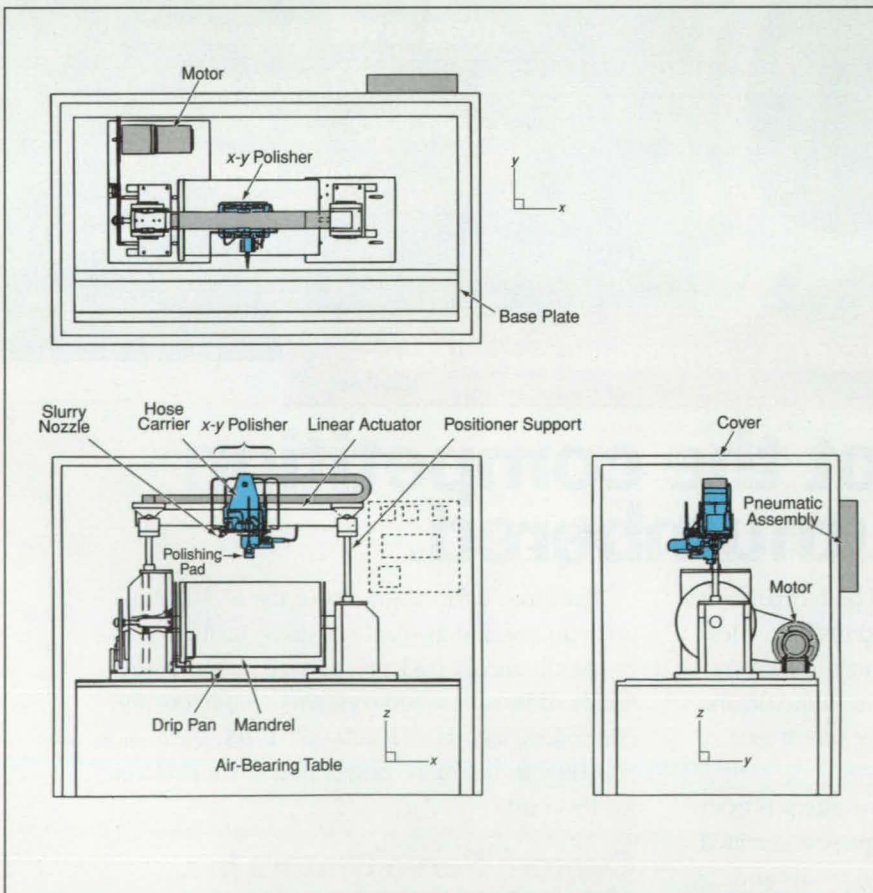
dinate system indicated in the figure, the axis of symmetry is horizontal and parallel to the x axis, y denotes the horizontal axis perpendicular to the axis of symmetry, and the z axis is vertical.

The polishing mechanism in this machine is an assembly called the "x-y polisher," which is mounted on a linear actuator above the mandrel. A hose delivers a polishing slurry to a nozzle on the x-y polisher, and the nozzle distributes the slurry over the surface of the mandrel. A drip pan below the mandrel catches the runoff slurry. The linear actuator is parallel to the x axis and is mounted on two positioner supports, at a height that is set manually at < 2 in. (< 5.1 cm) above the surface of the mandrel.

On command, the linear actuator translates the x-y polisher to the x coordinate of the spot to be polished. Then z-axis pneumatic pistons and cylinders are actuated to lower a polishing pad and press it against the mandrel. By controlling the pressure in the z-axis pneumatic cylinders, the pressure between the polishing pad and the mandrel can be set at any level from 0 to 100 psi (0 to 0.69 MPa). Similar pneumatic pistons and cylinders are used to move the polishing pad along the x and y axes in a commanded pattern, and linear variable-differential transformers (LVDTs) on the x and y cylinders furnish position feedback for the computer-based polishing control system. The maximum stroke of the x and y pneumatic pistons is 2 in. (5.2 cm). Because of the wide variety of polishing motions that can be commanded, material can be removed from the mandrel selectively, efficiently, and reproducibly to achieve the desired surface finish and contour.

This work was done by Frank P. Thomas, Lawanna Harris, Scott Hill, and Kathryn Horton of Marshall Space Flight Center. For further information, write in 86 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31131.

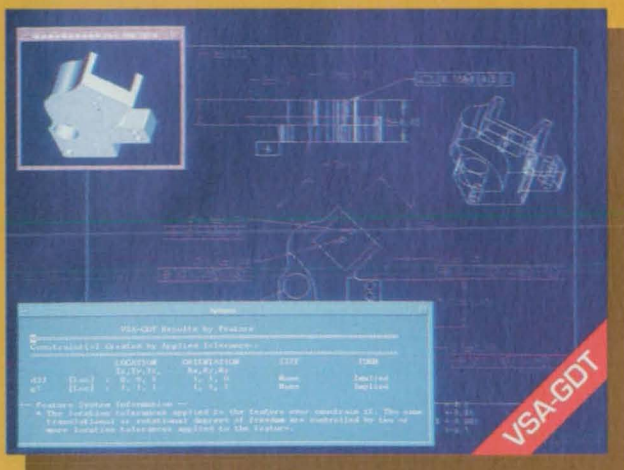


This Machine Brings the Benefits of Numerical Control to polishing of a cylindrical or nearly cylindrical axisymmetric mandrel.

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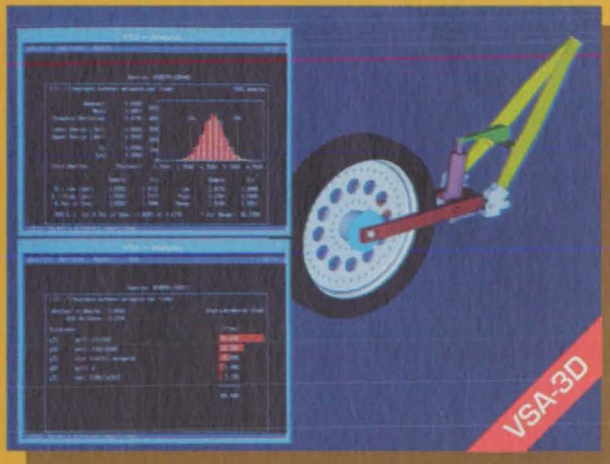
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Phase-Change Cooling for Motor/Generator/Flywheel in Vacuum

Active cooling would be unnecessary in low duty cycles.

Marshall Space Flight Center, Alabama

A proposed motor/generator/flywheel would be enclosed in a vacuum and its temperature rise in low-duty-cycle operation would be limited by use of a phase-change material. The specific motor/generator/flywheel was conceived for use aboard a spacecraft, but the underlying design concept is also applicable to low-duty-cycle machines in terrestrial vacuum chambers. Because of the thermally insulating proper-

ty of a vacuum, the dissipation of heat becomes a major consideration in design. The use of a phase-change material to limit the temperature rise can eliminate the mechanical complication, weight, and cost of plumbing, pumps, and radiators that would otherwise be needed for active liquid cooling of machinery in a vacuum.

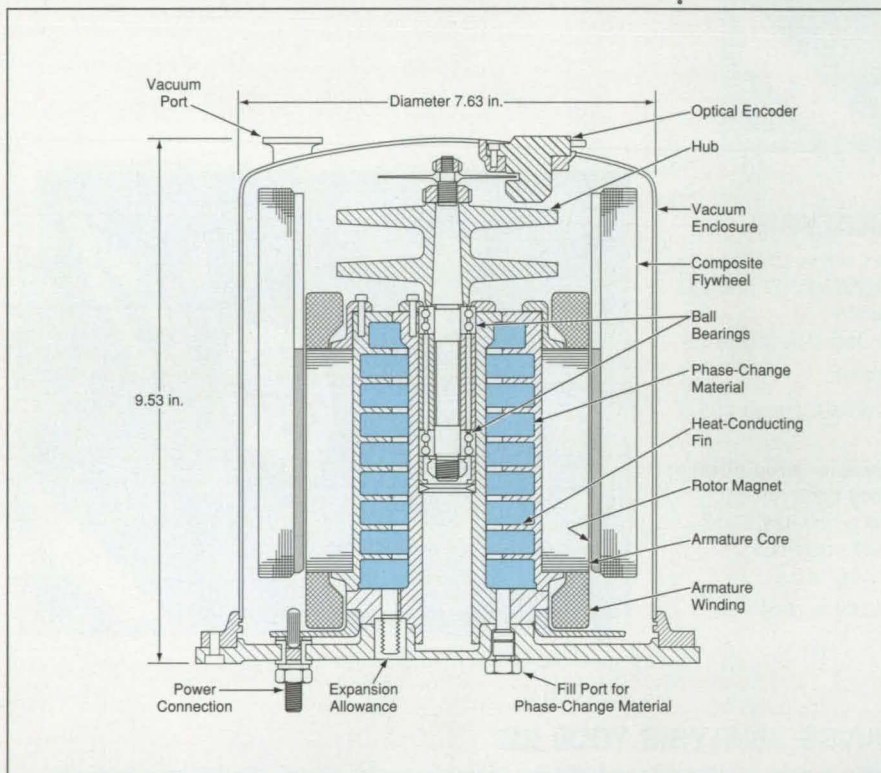
In the original application, cooling by phase change would be suitable be-

cause the motor/generator/flywheel would be required to coast most of the time and deliver bursts of power intermittently. A properly sized mass of phase-change substance could readily provide a sink both for low-level losses (during coasting) from bearing friction and the armature core and for short-duration losses during power bursts, maintaining acceptable temperatures throughout the system over a mission of prescribed duration.

The phase-change material would be contained in the stator in cavities between heat-conducting fins, close to the armature and the bearings (see figure). A promising phase-change material would be sodium hyposulfite pentahydrate, which melts at a temperature of 49 °C. The temperature of the motor could not rise much above 49 °C until the amount of stored heat was sufficient to melt all the material. Conversely, as heat gradually radiated away between operating intervals, the temperature of the motor would not fall much below 49 °C until all of the phase-change material had frozen. The phase-change substance would be returned to the frozen state at the start of a mission.

This work was done by Edmund C. Berk, James H. Goldie, and Richard T. Salter II of SatCon Technology Corp. for Marshall Space Flight Center. For further information, write in 92 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26341.



A Phase-Change Material (in this case, one that melts at 49 °C) would be contained in cavities between fins and would limit temperature excursions by absorbing or releasing latent heat of fusion during heating or cooling, respectively.

A Centrifugal Counter-Current Distribution Apparatus

This apparatus is capable of both rotary mixing and centrifugal separation.

Marshall Space Flight Center, Alabama

The figure illustrates the major components of a prototype of an improved counter-current distribution (CCD) apparatus for multistage extraction of materials of biochemical interest from two-phase aqueous mixtures. The prototype apparatus could be adapted to use in a

biochemical laboratory for extraction of cell organelles, particles, and macromolecules. It can also serve as a small-scale model of a large-scale extraction apparatus for downstream bioprocessing.

The apparatus includes disks that can be rotated within rings. The rotation of

the disks relative to the rings is accomplished by use of a stepping motor mounted on the axis of the disk-and-ring assembly. The axis of rotation is horizontal. The disks and rings contain equal numbers of radially oriented extraction cavities at equal angular intervals. The

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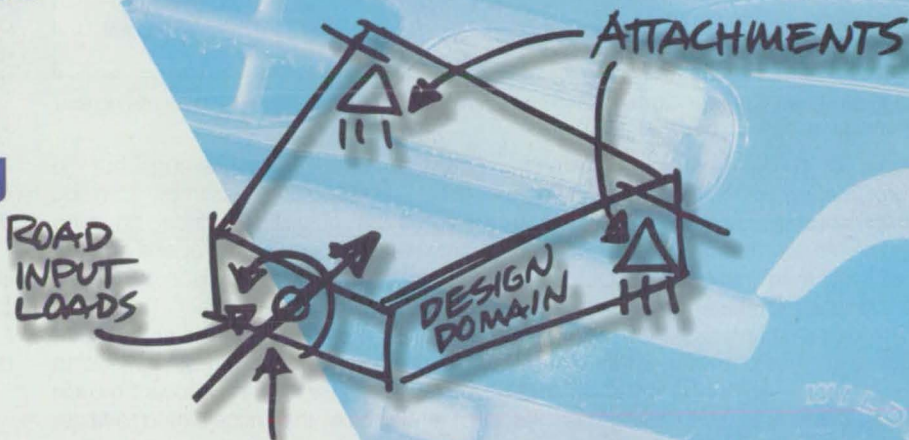
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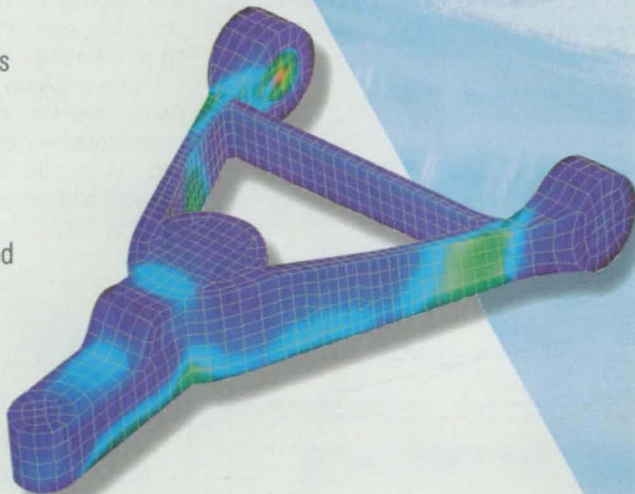
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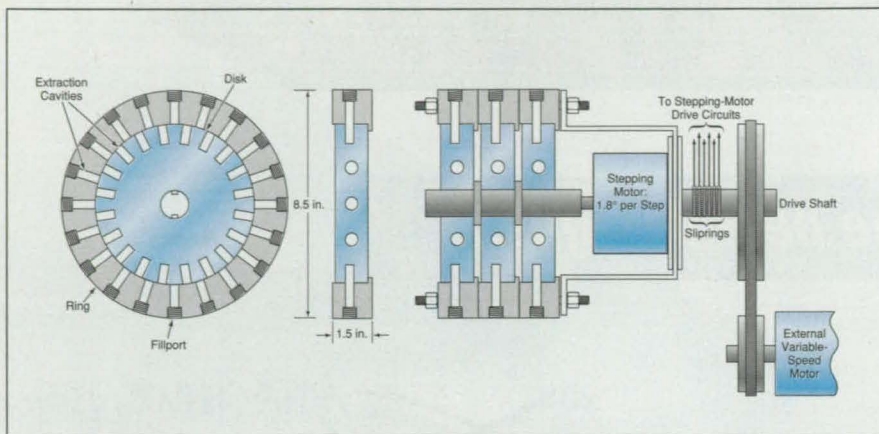


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This **Centrifugal Counter-Current Distribution Apparatus** can be used for both mixing and separation, and its operation is automated.

volume of a disk extraction cavity is approximately equal to that of a ring extraction cavity. Each disk fits in its ring precisely so as to permit relative rotation while sealing against loss of liquids from the extraction cavities.

The disk-and-ring assembly is mounted on a horizontal drive shaft that is driven via sheaves by an external variable-speed motor; that is, not only can the

disks be rotated within the rings, but the entire disk-and-ring assembly can be rotated as a unit. Electrical coupling between the stepping motor and stationary motor-drive circuitry is provided by sliprings on the drive shaft.

In operation, the disk-and-ring assembly can be slowly rotated as a whole to effect mixing through the buoyant motion of mixing balls, then accelerated to faster

rotation to accomplish enhanced centrifugal demixing (separation). Phase transfer is accomplished by step rotation (indexing) of the disks relative to the rings until the disk and ring cavities are aligned with each other. Indexing is performed during the final moments of the enhanced-demixing stage.

The apparatus is fully automated by use of an analog/digital electronic control system. By use of the control computer, the apparatus can be programmed to step through a specified number of extraction cycles of slow-rotation mixing and fast-rotation demixing with indexing, all with a minimum of involvement by a technician.

This work was done by Martin R. Guinn and Paul Todd of the University of Colorado for **Marshall Space Flight Center**. For further information, write in **37** on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26385.

Off-Line Base Placement of Mobile Robotic Manipulators

The off-line approach simplifies the control problem.

NASA's Jet Propulsion Laboratory, Pasadena, California

An off-line method of positioning the base of a robotic manipulator provides control functions analogous to those of a person finding a suitable place to stand in order to perform a task like wiping a table with a comfortable reach. The method is based on geometric reachability analysis.

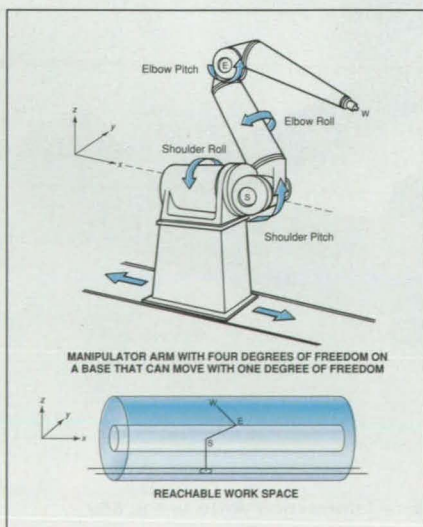


Figure 1. The Tip of the Manipulator Arm Can Reach any point within the cross-hatched hollow cylindrical volume.

In broad terms, geometric reachability analysis involves geometric analysis of the relationships among (1) the ranges of positions of the base, (2) the range of configurations of the manipulator arm mounted on the base, and (3) the target point, line, area, or volume reached by the tip of the manipulator arm.

Some previous articles in *NASA Tech Briefs* have described methods of coordinated control of both motion of the base and manipulation by the arm; because of the essential simultaneity of all controlled

motions, such methods are said to be "on-line." The present method is said to be "off-line" in that it applies to situations in which the base and the manipulator arm are not moved simultaneously; instead, once the base is placed in a position computed according to the method for a particular task, the base is held stationary while the manipulator arm is commanded to move to perform the task. The off-line approach is suitable for the large class of practical applications in which simultaneous motions of the base and the arm are not allowed because of operational constraints and considerations of reliability and safety. In addition, separation of the motions of the base and arm can be an important advantage in that it breaks the control problem into two simpler control problems, thereby enabling simplification of the design and operation of the robot-control system.

The present method provides a rational basis for automation of off-line base positioning, which heretofore has been done by time-consuming trial-and-error procedures under manual control. In the present method, the fundamental criterion for placement of the base is that the arm be

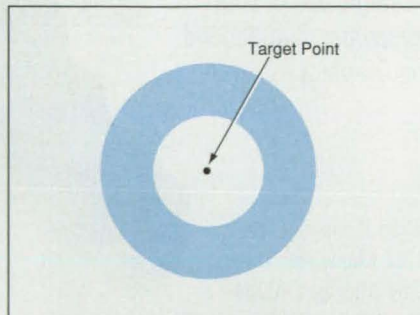


Figure 2. Placement of the Mobile Base of a manipulator arm anywhere within the cross-hatched region between two spheres would enable the tip of the arm to reach the central target point.

capable of reaching the target region without overextension or underextension. The range of preferred or allowable arm configurations, beyond which the arm would be considered to be overextended or underextended, is expressed by inequality constraints. Any constraints on the motion of the base (e.g., the base moves along a track) are also expressed by suitable equations.

The base-positioning problem is solved in stages. First, the entire locus of target positions reachable with preferred or allowable arm configurations is computed (see Figure 1). Next, provided that a given target lies within this locus, the locus of

base positions consistent with reaching this target and with the applicable constraints is computed. If there are multiple targets, then the feasible base positions are those that lie within the intersection of the loci of base positions for all the targets. The inequality constraints can be combined with additional constraints specified by the user to determine a unique base position.

Analysis of the method shows that for a robot with one-dimensional base mobility as in Figure 1, the locus of base positions from which a specified target point can be reached is a continuous portion of the x-axis, the length of which decreases with

increasing distance between the target and the x-axis. For a robot with two-dimensional base mobility (e.g., mounted on a rover), the locus of similarly feasible base positions is an annulus in the x-y plane. For a robot that can move in three dimensions, the locus of similarly feasible base positions is a volume between two concentric spheres (see Figure 2).

This work was done by Homayoun Seraji of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 24 on the TSP Request Card. NPO-19509

Heat Pumps Based on a Two-Phase/Two-Component-Fluid Cycle

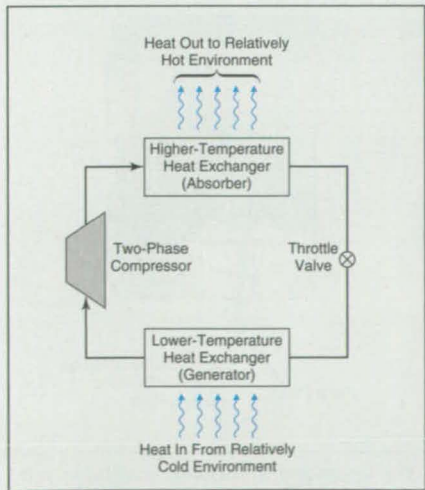
These heat pumps exploit both heat of mixing and heat of vaporization to enhance efficiency. *Goddard Space Flight Center, Greenbelt, Maryland*

Heat pumps based on a two-phase/two-component-fluid cycle are undergoing development. These heat pumps offer enhanced efficiency, and there is a potentially large market for them in domestic, commercial, and industrial heating and cooling systems.

The standards for comparison of the advantages and disadvantages of these heat pumps are (1) heat pumps based on the well-known conventional two-phase/single-component-fluid vapor-compression cycle used in most commercial refrigerators, air conditioners, and the like; and (2) heat pumps based on a lesser-known

conventional two-phase/two-component-fluid cycle known as the vapor-compression cycle with solution circuit. The two-component vapor-compression cycle with solution circuit achieves efficiency greater than that of the single-component vapor-

compression cycle by exploiting not only the latent heat of vaporization (and condensation) of a refrigerant fluid but also the latent heat of solution (and dissolution) of the refrigerant vapor and a refrigerant/absorbent liquid solution. Unfortu-



A Heat Pump based on a two-phase/two-component-fluid cycle schematically resembles a heat pump based on the conventional two-phase/single-component cycle, but differs in important details, including the choice of working fluids and the design of the compressor.

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nately, it is necessary to use a relatively complex, bulky apparatus in the two-component vapor-compression cycle with solution circuit to separate and join the flows of solution and vapor at various points in two overlapping flow circuits and to regulate pressures and flows accordingly.

The present heat pumps exploit the advantage (enhanced efficiency), but not the disadvantages (increased complexity and bulk) of the vapor-compression cycle with solution circuit. In a heat pump of the present type, no attempt is made to generate separate flows of vapor and solution; the vapor/liquid mixture is pumped as a single fluid around a single fluid circuit, in a manner similar to that of a conventional single-component vapor-compression heat pump. The means by which the heat pump absorbs heat from a relatively cold environment and rejects heat to a relatively hot environment are also similar to those of a conventional single-component vapor-compression heat pump, except for some important details related to exploiting both the latent heat of solution and the heat of vaporization.

The basic parts of the heat pump (see figure) are the plumbing, the two-component refrigerant/absorbent fluid, a low-temperature heat exchanger (also called a "generator" in this context), a two-phase compressor, a high-temperature heat ex-

changer (also called an "absorber" in this context), and a throttle valve. Heat from the relatively cold environment diffuses into the somewhat cooler fluid in the low-temperature heat exchanger, causing some refrigerant to vaporize, separate from the refrigerant/absorbent solution, and become slightly superheated. The resulting vapor/solution mixture flows to the two-phase compressor, which discharges the mixture to the high-temperature heat exchanger at higher pressure and temperature.

The two-phase compressor features a special design that eliminates the knocking often associated with compression of liquid/gas mixtures and that ensures rapid, nearly adiabatic compression. Rapidity of compression is necessary for reasons that are best explained by describing the next stage of the cycle: It is desired to transfer heat to the relatively hot environment via the higher-temperature heat exchanger. For this purpose, it is necessary to compress the fluid mixture enough to force the refrigerant vapor to redissolve into the solution, with consequent release of both latent heat of solution and latent heat of vaporization. To maximize the transfer of heat via the heat exchanger to the environment, this redissolution of vapor and release of heat should take place as much as possible while the fluid mixture flows through the heat exchanger and as little as

possible during the preceding compression. Thus, compression should be rapid.

After discharging heat and leaving the higher-temperature heat exchanger, the fluid is throttled to lower pressure and temperature. The fluid then flows to the lower-temperature heat exchanger, completing the cycle.

The refrigerant and the solution or the absorbent fluid can be chosen from among many candidate pairs of fluids, depending on the specific heat-pump design. A number of these pairs are nontoxic, (or only slightly toxic) and do not contribute to depletion of ozone or otherwise harm the environment. A typical example would be with HFC-134a as the refrigerant and a nontoxic, high-boiling organic liquid as the absorbent.

This work was done by Steve M. Benner of Goddard Space Flight Center and Robert P. Scaringe, Fulin Gui, and Lawrence R. Grzyll of Mainstream Engineering Corp. For further information, write in 52 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13715.

Improved System for Cryopumping of Xenon

Size, weight, and cost are reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

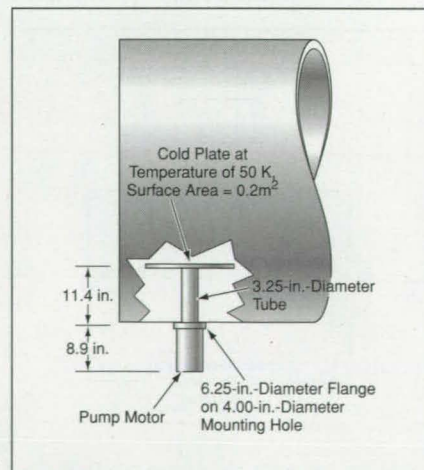
An improved cryopump removes xenon from a vacuum chamber at a rate of 16,700 L/s. This cryopump weighs only 60 lb (27 kg); is mounted via a hole 4 in. (10 cm) in diameter in the vacuum-chamber wall; and costs about \$16,000 (1995 prices), as installed, so that its unit xenon-pumping cost is approximately \$1/(L/s). In contrast, a typical cryopump or diffusion pump of older design with equivalent pumping capability weighs 554 kg (1219 lb); must be mounted in a 48-in. (122-cm) hole in the vacuum-chamber wall; and costs \$100,000 including installation. The price of these pumps alone ranges between \$65,000 and \$120,000, with consequent unit xenon-pumping cost around \$6/(L/s).

The improved pump (see figure) is a modified version of a commercial cryopump that operates on the Gifford-McMahon cycle. The modification con-

sists largely in the removal of chilled baffles that are ordinarily included in cryopumps to reduce the thermal loads on the cold plates of the pumps. These baffles reduce pumping speed to about one-fourth the level otherwise attainable. The improved pump delivers 105 W of cooling power at a temperature of 50 K; this cooling power is about 5 times that of a two-stage cryopump of older design operating at the lower temperature of 20 K.

This work was done by Charles Garner of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 51 on the TSP Request Card.

NPO-19967



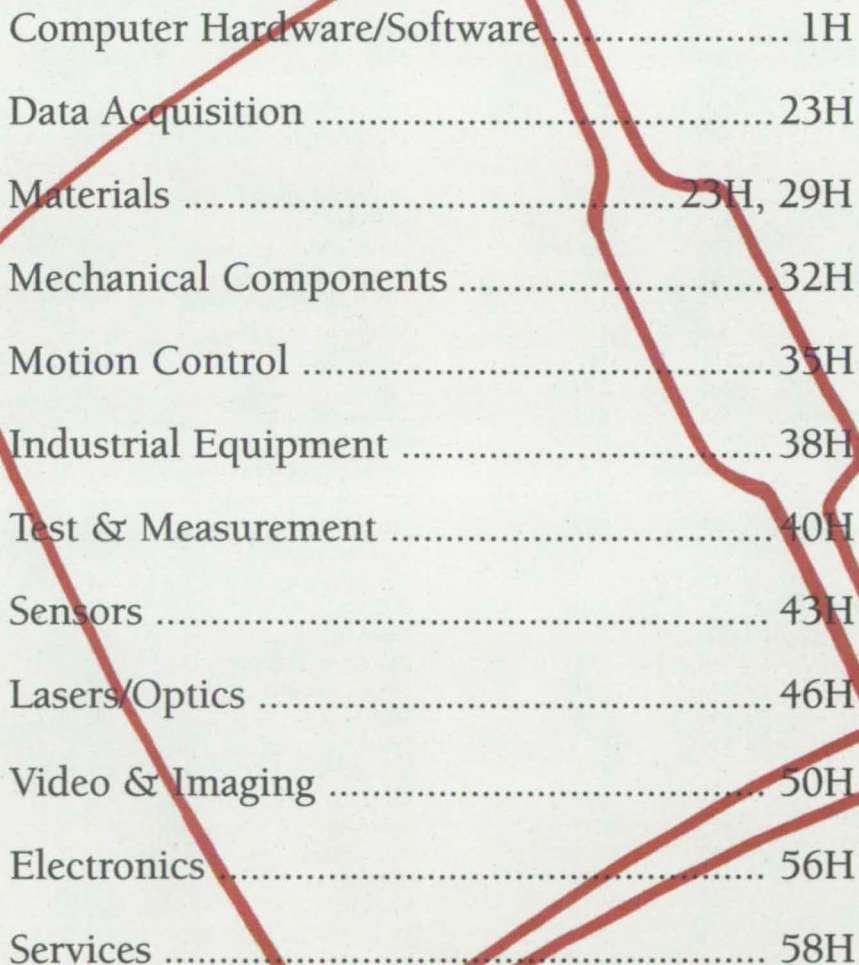
The Improved Cryopump is installed without chilled baffles, which would reduce pumping speed if they were included. The cost and complexity of installing and operating these cryopumps is a fraction of the cost and complexity to install and operate diffusion pumps or standard cryopumps that deliver similar pump speeds on xenon.



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Supplement to NASA Tech Briefs December 1996 Issue

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CYBERNETICS

Based in Yorktown, VA, Cybernetics manufactures, sells, and services leading-edge tape and disk storage solutions with capacity from 2 gigabytes to hundreds of terabytes. We have spent nearly 20 years providing businesses worldwide with the products they need to streamline their data storage operations. Our complete family of products includes 8mm, 4mm, DLI, DTF, magneto-optical, hard disk, and RAID technologies. We are widely recognized for our intelligently engineered products that enable customers to work more productively, save resources,



and adapt to the ever-changing demands of information systems management. A commitment to research and development allows us to engineer the most advanced data storage solutions on the market, and it also allows us to provide a level of service and technical support that is unrivaled in the industry.

Products and Applications

From high-speed tape and optical disk subsystems to hard disk and RAID configurations, Cybernetics solutions set the standard for performance, reliability, and data integrity. Our tape and disk subsystems are plug-compatible with virtually every computer system and network running. We are unique in our ability to connect to the fastest host systems with ESCON, Fibre Channel, and Ultra SCSI interfaces to meet the speed and capacity demands of high-performance systems. Customers can choose from our exclusive options to customize their solutions for maximum performance and operating efficiency on every level. Options include data compression to increase capacity and transfer speed by up to five times; Data Encryption to protect sensitive information; the Advanced SCSI Processor to extend flexibility with five



recording modes; the Digital Data Recorder to write data directly from Analog-to-Digital converters; Robotic Control Software for complete library automation; and Accelerated File Access for fast file searches.

The Digital Data Recorder Interface

The most advanced data collection applications require our Digital Data Recorder (DDR) interface. The DDR allows you to write directly to tape from analog-to-digital converters or other instrument recorders, saving time and money when performing tasks such as seismic surveying, radar data recording, and telemetry. A variable rate data buffer of up to 128 MB ensures a smooth flow of data from host to drive, regardless of fluctuations in the data source. With the DDR, you can achieve transfer speeds of up to 36 MB per second and support as many as 80 devices.



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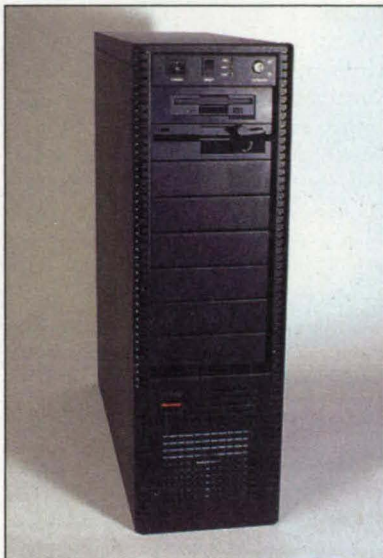
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Microway

Since 1982, Microway's products and technical support have helped users get more done for less money. Starting with the concept that PCs could use more numeric power, we built a product line and customer base that is now worldwide. The products we sell today use Alphas and i860s that deliver 20,000 times the throughput of the 8087s we started with in 1982. For the last four years, we have been building systems that provide up to 2 gigaflops of throughput using parallel i860s. The 500 MHz DEC Alpha that powers our current product line delivers 1 gigaflop by itself! If you have an application that is a big-time number-cruncher or a DSP application which needs more than 32 bits of precision, you should consider our solutions.

One of the problems with getting more done for less is tech support — most expensive PC tools are not supported. Our service starts with the use of the telephone: when you call us you talk to a competent person. Because we appreciate the critical nature of your work, every one of our products comes with free tech support for one year. This means we charge a little more for our production-grade compilers, but they still cost much less than the mini or mainframe tools of the past. Our excellent tech support makes it possible for us to quote your favorite DEC UNIX and OpenVMS systems, yet also deliver NT and Linux. And we know how to take care of special situations, including rack-mounted industrial-grade systems and RAID-controlled hard disk farms.

Microway's current product line is anchored by NDP Fortran and C/C++, which are available for Pentiums and generate Alpha code for DEC UNIX, NT, and Linux. These translators grew up in the 32-bit x86 DOS Extender markets of the mid-80s, and have been ported to a number of devices and operating systems. From 1986 to 1995, this included Transputer and i860-based cards that employed up to 4 CPUs per card. Using Microway QuadPuters, it became possible to build systems that employed dozens of processors.



In late 1995, we started to deliver Alpha-based workstations with motherboards built in-house. The line will shortly be extended to include parallel solutions and motherboards that have special industrial features.

Our customers for Alpha systems include most of the major universities and government labs. Typical applications run as fast on a 300 MHz 21164 as they do on a Cray

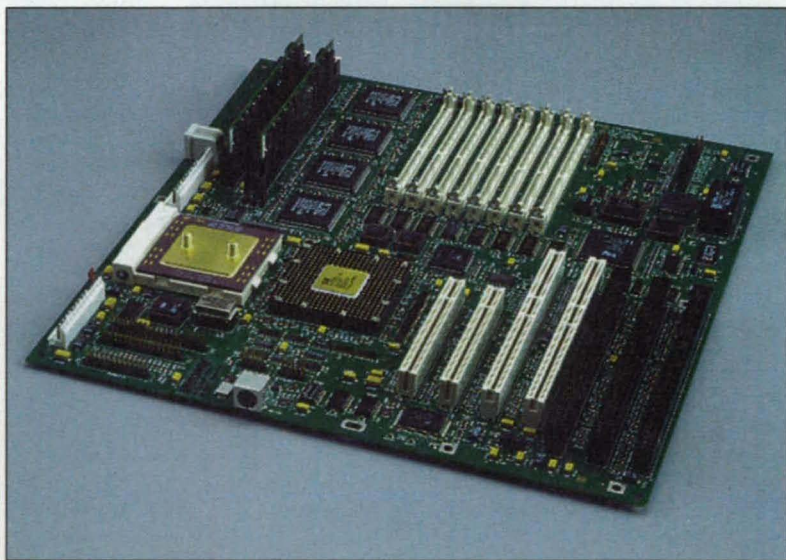
instructions per clock, but to lead loads ahead of their uses. This helps to reduce the latency of caches and memory.

Microway hardware products have always been popular with government, industry, and university researchers. Our i860 powered cards were used to search for oil, improve MRI resolution, do air flow studies on jet engines, and help the NASA SETI project search for extraterrestrial life. An NT-powered Alpha Screamer currently is being evaluated by NASA to control shuttle missions, while a government agency is now using Screammers to run neutron scattering simulations in minutes that used to take days.

Company History

Microway was founded in 1982 to help scientists and engineers take advantage of the IBM-PC. Our first product was a library, which made it possible to use an 8087 in a PC. We bundled our libraries with 8087s and became one of Intel's largest customers.

Our hardware products included PC accelerators, coprocessor cards, and motherboards. In 1986, we introduced the first 32-bit Fortran to run on an Intel PC. The first PC to hit a megaflop used a Microway/Weitek coprocessor driven by NDP Fortran.



Y/M.P. Our current 500 MHz product employs faster caches, which help its speed scale with frequency. It delivers 150 Linpack megaflops and dot products that hit 940 megaflops.

To take advantage of the Alpha's enormous power, we have developed a scheduler that not only makes it possible to issue four

Over the years, NDP Fortran has been used to port hundreds of popular mainframe applications, including MATLAB and ASPEN, to Intel-based PCs.

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Gary Ball
Vice President
Government Systems Area

At Silicon Graphics, our commitment to government is long-term, and our extensive list of government and federal customers attests to our promise of developing high-performance visual and enterprise computing systems.

Take our involvement with NASA, our first and largest customer. For the past 14 years, we've provided solutions for nationwide NASA centers in a wide range of applications. From visual simulation to chemical modeling to computational fluid dynamics, we've proven that Silicon Graphics is dedicated to providing innovative solutions to the government market.

I'm thrilled that we've received preferred vendor status with the NASA SEWP II project. And with the creation of our new Government Systems Area, we've amplified our focus on meeting the requirements of the federal government.

As the needs of government customers continue to grow and push the technological envelope, we look forward to creating the most innovative, performance-driven tools to help solve these unique and complex problems.



SiliconGraphics
Computer Systems

Silicon Graphics/Cray Research continues its commitment to government business by providing leading-edge solutions in the areas of defense imaging, visual simulation, command and control, and engineering.

We recently announced our broad new line of computer products, including the new O2 workstation line, which replaces the Indy workstation and provides 10 times more computing power. O2 includes integrated Web authoring tools, 3D graphics with texture mapping, image processing, and video compression capability – starting at a remarkable list price of \$5,995.

The Indigo2 IMPACT 10000 workstation continues to be the Silicon Graphics high-performance workstation with hardware-accelerated graphics, the fastest available on any desktop.

The new Onyx2 workstation family, with significantly increased graphics processing

speed, is designed to tackle the most demanding visual computing challenges. Onyx2 offers high-end graphics systems to a broader market range.

The high-performance Origin server family can expand from single processor desktop systems to powerful 128-processor scaleable servers without disruptive and expensive box swaps. From our entry-level desktop to our high-end supercomputers, Silicon Graphics provides a family of scaleable, high-performance products that integrate seamlessly into a multi-platform environment.

With the formation of the Government Systems Area, Silicon Graphics plans to provide and promote high-performance computing, world-class visualization technologies, and unsurpassed customer support throughout the government market.



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Virtual Vision

The V-Cap™ 1000 Digital Head-Mounted Systems: Productivity Tools for Demanding Work Environments

The Virtual Vision V-Cap 1000 Digital Head-Mounted System (DHMS) presents computer information through audio and visual formats in professional and industrial applications. Mobile users can access graphic data through the patented display device, which layers images over the work plane, and audio feedback through a noise canceling microphone and speaker system. Use of an advanced speech recognition system enables hands-free computer connectivity in customized applications.

Augmented Reality

The V-Cap offers the benefits of augmented reality. Unlike virtual reality, which tries to immerse the user in a synthetic environment, augmented reality adds information to the user's immediate environment. Data is supplied when and where it is needed to enhance the user's performance of the task at hand, seamlessly integrating information and activity.

The V-Cap 1000

The V-Cap is the leading DHMS for industrial applications.

- Display: 640 x 480 pixel monochrome
- Optics: Monocular see-through
- Format: VGA (NTSC optional)
- Ruggedized: Against dirt, humidity, and shock
- Power Requirement: 3.5 watts typical
- Gray Scale Linearity: Absolute $\pm 5\%$

640 x 480 pixel resolution and highly linear gray scale halftones offer clear and precise images of complex information. Demanding graphics applications, such as digitized maps and complex wiring schematics, can be clearly presented on the V-Cap. These images are displayed on a patented see-through optic that can be focused on the work plane and is transparent when not in use. It is also resistant to environmental con-



ditions such as dirt, moisture, and shock.

The audio interface with computer information is comprised of a noise-canceling microphone and speaker system. The microphone favors the user's voice and filters ambient noise. The speaker is fully adjustable for comfort.

The electronics are mounted on modular platforms and can be moved from one Neoprene cap to another. The caps can be washed, and are a hygienic, cost-effective solution to buying multiple units.

Speech Recognition

An optional speech navigation system enables application development to create custom syntaxes for hands-free computer navigation. Spoken commands are translated into actions the computer can execute, and

textual information can be translated back into speech. Continuous-speech and speaker-independent operation help the V-Cap fuse information with mobile work activities.

A Productivity Tool

The V-Cap unifies various technologies to create a product that is comfortable and easy to use. By eliminating the need to shift from information sources to work activities, users stay focused on work activities, increasing accuracy and productivity.

The V-Cap 1000 is the foremost data delivery system for professional and industrial applications which require mobile, hands-free information in demanding environments.

About Virtual Vision

Virtual Vision®, a member of Telxon Corporation's Technical Subsidiaries Group, is engaged in the development of Digital Head-Mounted Systems (DHMS) for indus-



trial applications. Successful field tests of the Virtual Vision DHMS at Boeing, NASA, Carnegie Mellon University, and other industrial programs and production of more than 15,000 units gives Virtual Vision a leadership position in this emerging technology. Virtual Vision continues working to expand the frontiers of mobile computing by integrating DHMS technology with speech recognition systems, body-worn computers, and wireless communications.

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E-mail: techinfo@virtualvision.com

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CADSi®

Discover the Reality of Simulation Driven Design

In today's competitive manufacturing environment, moving products to market faster with less cost has become much like the ancient search for the holy grail – an extremely rewarding yet elusive quest that is full of perilous pitfalls. The engineering mantra that time is money makes it critical for companies to manufacture quality products from designs that work right the first time. The delays and costs involved in the traditional design-build-test-redesign rebuild-retest cycle have made it apparent that the best place to save time and improve the product is during the design stage, before major manufacturing tooling costs are incurred.



Many methods and plans have been implemented in this quest, including software for the analysis of mechanical assemblies and components, which is now an accepted tool in the mechanical engineering process. However, analysis typically has required the building of separate models by analytical specialists and has not always resulted in significant time savings. In order to reduce these delays, the logical evolution of simulation software has been to integrate it with design programs.

Computer Aided Design Software Inc. (CADSi®) is the industry leader in developing CAD integrated analysis software for Simulation Driven Design™. By performing simulation directly in the CAD program, more components and assemblies can be analyzed. It also ensures that the analysis is being performed on the most current CAD model, elim-

inating redundant modeling. The dramatic reduction in the time required to perform simulation significantly streamlines the design and analysis process.

Integrated simulation tools also support a collaborative engineering environment in which a CAD master model database serves all stages of design, analysis, testing, and manufacture. A major advantage of CADSi's simulation software is the strategic and seamless integration with CAD programs such as CATIA, IDEAS Master Series, and Pro/ENGINEER, as well as control programs like MATLAB, MATRIXx, and EASY5. This integration with CAD and control programs enables the crea-

tion of realistic, total system prototypes.

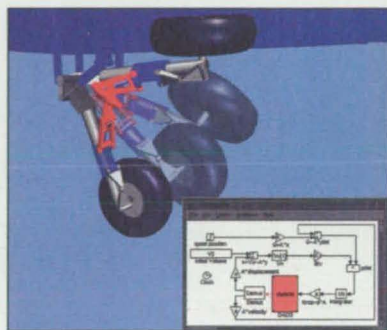
CADSi's vice president of business development, David Bird, states that, "The value of integration is that it guarantees that all simulation and analysis is being performed on the most current CAD model, enabling results to immediately drive design improve-

ments. This process of simulation driving design increases productivity, improves design performance, and enables our customers to bring their products to market faster."

Beyond the Hype, What's Real?

An agricultural manufacturing customer reported that on a recent project, using traditional design-test methods would require six months and \$300,000. By using CADSi's simulation software, they reduced their time to six weeks and their costs to \$60,000. The technical director at a major sporting goods manufacturer stated that, "our confidence in simulation results from CADSi's software integrated in the CAD environment enabled us to eliminate a full year of physical tests and rework."

CADSi's simulation products are used worldwide by major companies – including Boeing, BMW, CASE, Chrysler, Deere & Company, Ford, Honda, Mercedes-Benz, NASA, Samsung, and Toyota – as they forge ahead on their mission to be first to market with the best products. The common thread

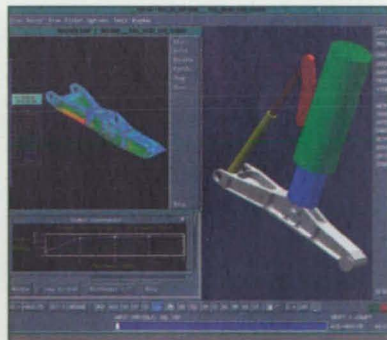


among these companies is their understanding of the value of implementing integrated simulation and analysis early in the design phase.

The Reality is Simulation Driven Design

Simulation Driven Design assists in identifying critical design parameters early in the development process. It supports collaborative engineering by bringing product development teams – consisting of designers, dynamicists, structural engineers, and control engineers – together in an integrated design process. The CAD program provides the common model database and CADSi's simulation software performs dynamic system simulation of assemblies, structural analysis of components, and integration of control systems with the mechanical model.

Visualization of product designs through plotted results and animation in the CAD



environment assure engineers that their designs meet their criteria before committing to hardware. Ongoing development among CADSi, their industry partners, and their customers ensures that Simulation Driven Design is well on its way to securing the holy grail of manufacturing by delivering on the goals of shortened time to market, reduced costs, and improved product quality.

CADSi
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E-mail: marketing@cadsi.com
www.cadsi.com

Circle No. 812 On Fax Form

Corel: The Leading Edge

Whatever you need your software to do, Corel can make it happen.

Over the past year, Corel Corporation has broken into many new areas of the software market, making it the world's second-largest vendor of productivity applications. Business leaders and decision-makers everywhere are discovering what this kind of aggressive growth means for them: innovative, powerful solutions for their computing needs. With Corel, anything is possible.

New areas include:

- the office suite market, now energized by Corel® WordPerfect® Suite and Corel® Office Professional – which took a 50% market share of retail office suite sales† within three months of their release
- the CAD market, with CorelCAD™ for 3D solid modeling and Corel® Visual CADD™ for drafting and design
- the desktop videoconferencing market, with CorelVIDEO™
- the emerging market for Java™ technologies and thin client computing, where Corel® Office for Java™ is the only contender in a new computing paradigm.

†Data received from PC Data, the most credible and comprehensive auditor of software sales in the U.S. Based on unit sales for MS-DOS, Windows® and Windows® 95 products at retail, June 1996.

Corel Corporation
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www.corel.com



Corel: Ideas in Action

Letting your ideas take shape is a simple, intuitive process with Corel's powerful CAD products. Here's what they offer:

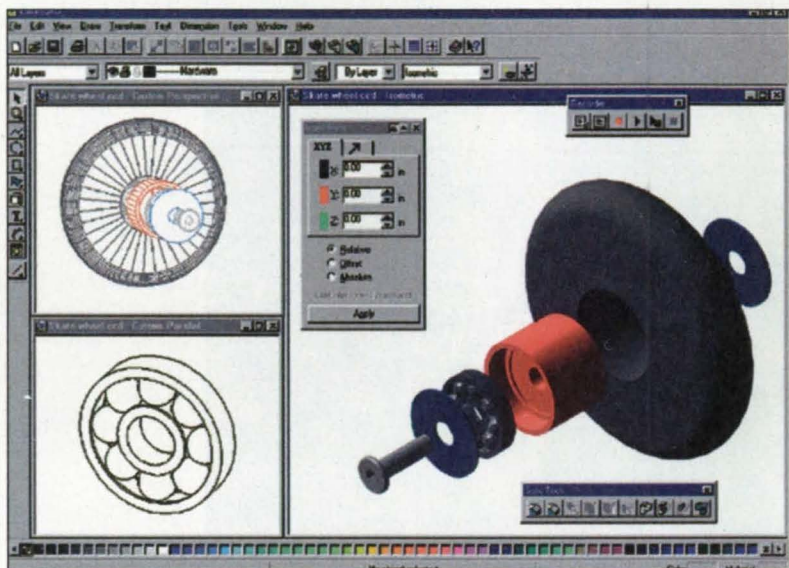
CorelCAD™:

- a 32-bit, 3D design tool
- the industry-standard ACIS solid modeling system
- a fully customizable interface
- powerful Boolean operations
- advanced blending, extrusions, and 2D drafting features
- exceptional rendering capabilities for realistic shading and textures

CorelVIDEO™ will help you take the next step in communications through the effective use of advanced video technology. Here's what it offers:

- increased workgroup awareness and productivity
- face-to-face communication across the hall or across the world
- simple point-and-click interface with a video phonebook
- call waiting, call transfer, speed call, and Do Not Disturb
- built-in privacy safeguards

Another key to 21st century information



Corel® Visual CADD™:

- a fast, efficient 32-bit professional design and drafting tool
- fully compatible with AutoCAD's DWG and DXF and GenericCADD® file formats
- intuitive interface for new and experienced users
- compatibility with both Windows® 95 and Windows NT™ environments

Corel is synonymous with graphics excellence. CorelDRAW™ holds an 85% market share in PC graphics products and CorelDRAW™ 7, the latest release, promises to expand on that. The same graphics excellence is now translated into the CAD market.

Experienced CAD users will find ease of use, precision, and remarkably powerful tools in CorelCAD and Corel Visual CADD. Advanced users of CorelDRAW will benefit from the power for specialized design projects that CorelCAD provides.

But Corel's products don't just help you develop your ideas. They help you share them.

sharing is Internet connectivity. Corel® WordPerfect® Suite and Corel® Office Professional give you unparalleled Internet integration.

With Corel Barista™, Corel's unique Java™ publishing technology included with the suites, you can publish your documents, exactly as they appear, to the Java™ language. No other suite allows you to do that.

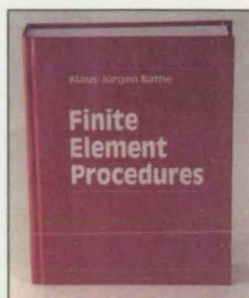
Corel® Office for Java™ is now available for preview on Corel's Web site (www.corel.com) and is scheduled for release early in 1997. It is the world's first office suite written exclusively in the Java language.

With CorelCAD and Corel Visual CADD, your ideas come to life. With CorelVIDEO and Corel's Internet products, communicating your ideas becomes fast and effortless.

Circle No. 813 On Fax Form

ADINA

Finite element analysis in engineering product design is now well-established. Commonly, organizations use various computer programs for specific tasks of finite element analysis, and these individual programs are to various degrees integrated in the computer-aided design process. For example, one finite element program is used for linear static and dynamic structural analysis, another program is used for acoustic analysis, and yet another program is used for nonlinear structural analysis. For nonlinear dynamic

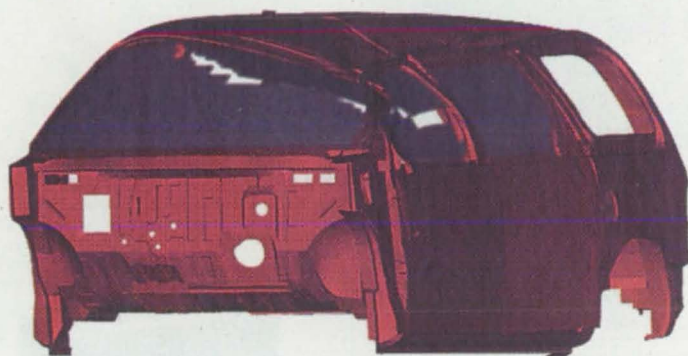


analysis using mode superposition, explicit or implicit time integration can be performed.

Restart from one type of analysis to another is directly possible. Fluids can be modeled as acoustic fluids, or incompressible or compressible fluids governed by the full Navier-Stokes equations.

In fluid flows with structural interactions, completely different mesh discretizations can be employed for the structure and the fluid. The solvers of the program system are fully supported by in-house developed pre- and

ADINA



analysis, frequently also different explicit and implicit codes are employed. In addition, finite volume-based programs may be used for fluid flow analyses, and virtually no capability is available to analyze complex fluid flows with structural interactions.

The mission of ADINA R & D is to provide one effective finite element program system – the ADINA System – that can be used to perform comprehensive finite element analyses of structures, fluids, and fluid-structure interactions.

The use of one program system that is fully integrated for structural and fluid flow analyses, and that therefore can be used instead of a series of other analysis codes, provides for a tighter integration of the complete analysis process in the CAE environment, less cost, and higher reliability and effectiveness.

The ADINA System is unique because of its wide range of analysis capabilities. Structures can be modeled as linear or highly nonlinear, including material nonlinearities, large deformations, and contact. Static analysis, frequency solutions, or transient

post-processing, including automatic meshing, and the system can also directly be employed with CAD programs such as Pro/ENGINEER, by accessing the geometry and I-DEAS or PATRAN, by using their databases.

The generality, effectiveness, and reliability of the ADINA System are due to the specific finite element procedures, the sparse matrix solution techniques, and parallel processing used. Many of the techniques are described in the textbook, *Finite Element Procedures*, by K.J. Bathe (Prentice Hall, 1996).

Company History

ADINA R & D, Inc. was founded in 1986. However, a graphical user interface for pre- and post-processing and effective CAE connection was lacking until 1996. The new emphasis on ease of use of the ADINA System has rendered the System a very attractive analysis tool in many industries. More information on ADINA R & D is given on the Web at: www.adina.com.

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Circle No. 814 On Fax Form

Algor, Inc.

Algor, Inc. is an international company providing a broad range of technology-based products and services to the engineering community. More than 12,000 engineers in more than 60 countries use Algor software for finite element analysis and design optimization.

Algor has an extensive World Wide Web site at <http://www.algor.com>. Video clips and animated demonstrations give engineers a virtually live presentation of what Algor products can do for them. A new demonstration is available each week on topics ranging from nonlinear stress and dynamics to fluid flow analysis.

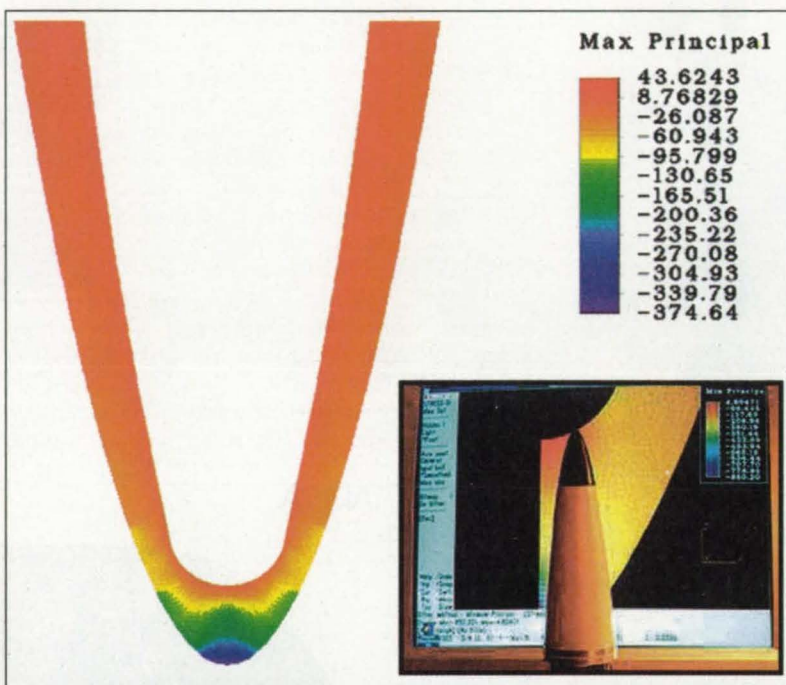


Houdini automatically converts CAD solid models to 8-node "brick" meshes for more accurate finite element analysis.

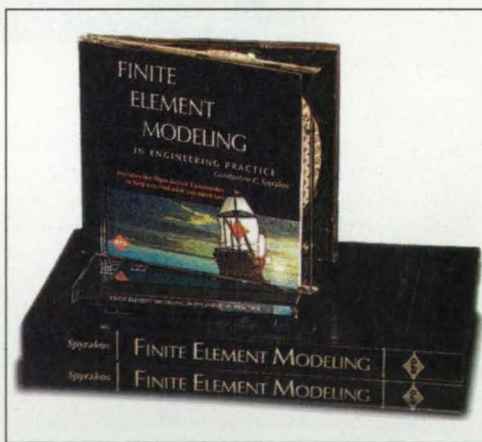
Algor's web site also contains product information, free software downloads, technical tips, case histories from engineers who use Algor software, the latest editions of Algor's newsletter, *Algor Design World*, and much more.

The complete contents of Algor's web site are available on a free CD-ROM. The CD-ROM provides valuable information about how to design safer, more economical products in a convenient, high-speed format.

Algor has created unique software products such as Houdini, the first and only software to convert a CAD solid model created in any major CAD system into an eight-node "brick" finite element mesh for use with virtually all major FEA software, and the



This rocket nose cone was analyzed as part of a project to design a 2.75-inch air-launched, free flight artillery rocket (FFAR). Inset shows the nose cone prototype in front of the designer's computer screen. The complete story can be accessed on Algor's World Wide Web site (<http://www.algor.com>) or on the new Algor Web site CD-ROM.



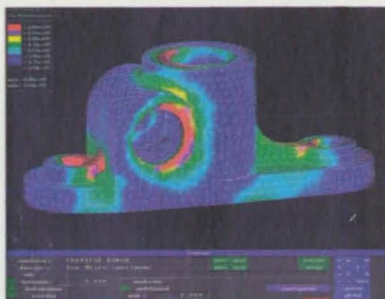
Finite Element Modeling in Engineering Practice, the engineering best-seller by Dr. Constantine Spyarakos, is now available on an interactive multimedia CD-ROM.

Integrated Plant Package (IPP), a complete set of design and analysis tools for the piping and vessel systems, designed to aid engineers in the industrial plant design market.

Algor's Publishing Division (APD) publishes and distributes books, videos, and multimedia products, which help engineers in industry and academia do better design and analysis with all types of engineering software. *Finite Element Modeling in Engineering Practice*, the engineering best-seller by Dr. Constantine Spyarakos, is now available on an interactive, multimedia CD-ROM.

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www.algor.com

Circle No. 827 On Fax Form



NEW! 1000 Elements/Second – Super-fast, high-quality, automatic tetrahedral mesh generation added to HyperMesh v. 2.1.

Upon its introduction, HyperMesh became the highest-performance finite element pre- and post-processor available. The HyperMesh high-speed tradition continues with the introduction of new tetrahedral (tet) automatic mesh generation capabilities. The new HyperMesh tet-mesher is capable of generating as many as 1000 elements a second on standard UNIX workstations. But perhaps even more important is element quality. In benchmark tests with other systems, HyperMesh consistently produced a larger proportion of high-quality elements as measured by interior angles, skew, and collapse ratio. Users also have a wide range of control over the meshing process to ensure successful mesh completion without an excessive number of elements. This means that with even the most difficult geometry, HyperMesh can reduce modeling time dramatically. The tet-mesher is also available with an API as component technology for use in other applications.

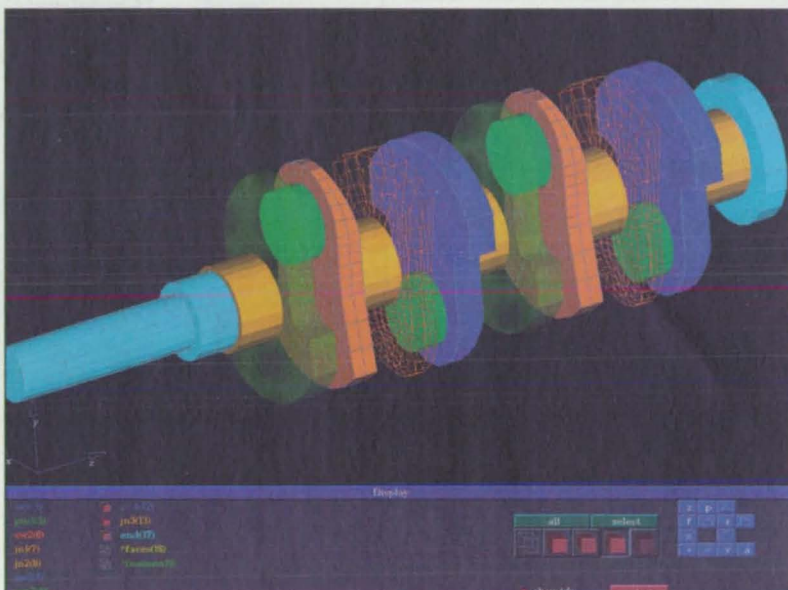


High-Performance Software for Engineering Simulation

Altair Computing, Inc. provides advanced engineering solutions that allow customers to drive their design process right from the start, while increasing overall process productivity at each step. The company's flagship product is the HyperMesh finite element pre- and post-processing software. Altair has

sis. OptiStruct effectively addresses optimization of design layout based on package space and loading conditions.

MotionGen and MotionView – New generalized pre- and post-processing software packages that enhance major mechanical systems codes by providing an open, easy-to-use graphical system for parametric system model construction, animation, and XY data plotting.



Outstanding visualization in HyperMesh.

also introduced award-winning design synthesis software and high-performance pre- and post-processing tools for mechanical systems simulation.

HyperMesh – HyperMesh is a generalized pre- and post-processor for major Finite Element Analysis codes. HyperMesh strengths include: very-high-speed interactive performance, outstanding post-processing visualization, ability to effectively work with large models, and ease of use. It is well-accepted by thousands of users in the U.S., Asia, and Europe.

OptiStruct – Opti-Struct, awarded "Technology of the Year" and a NASA Tech Briefs "Product of the Month," is a new technology for topology optimization or design synthe-

Altair Background

Altair Computing's commitment to application-focused innovation is deeply rooted in its history. The company grew out of Altair Engineering, which was founded by a group of engineering experts in 1985 to provide structural analysis services. Altair's philosophy is to hire the most talented engineering professionals, offer them the most advanced software tools available, and give them the freedom to apply their creativity to the industry's toughest problems. Today, Altair remains dedicated to these principles. Altair's consultants continue to experiment with the best engineering analysis tools on the market to ensure that clients are offered solutions that truly give them a competitive edge in product development.

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Circle No. 824 On Fax Form



Paul L. Graziani
President and CEO

Space provides the last frontier for research and exploration. While the possibilities are vast, nations can be restricted by limited financial resources.

Analytical Graphics, Inc. is committed to developing solutions such as Satellite Tool Kit, which enable the space community to do more powerful and swift analysis, in a competitive environment, with less money. We believe strongly in our nation's proven ability to make great strides in space, and we are proud that our tools – recognized as the industry standard – have continually been rated #1 in numerous independent government studies.

Many programs within NASA are extensive STK users. As budgets shrink, they find that the competitive edge provided by STK is invaluable in analysis and visualization efforts. STK customers get the most accurate solutions, faster and cheaper than with any other legacy or commercial tool. Furthermore, they report being 5 to 100 times more productive with our software, which pays for itself in four months.

Our primary goal at AGI is to continually bring tools to the space community that deliver success in analysis and gains in productivity.

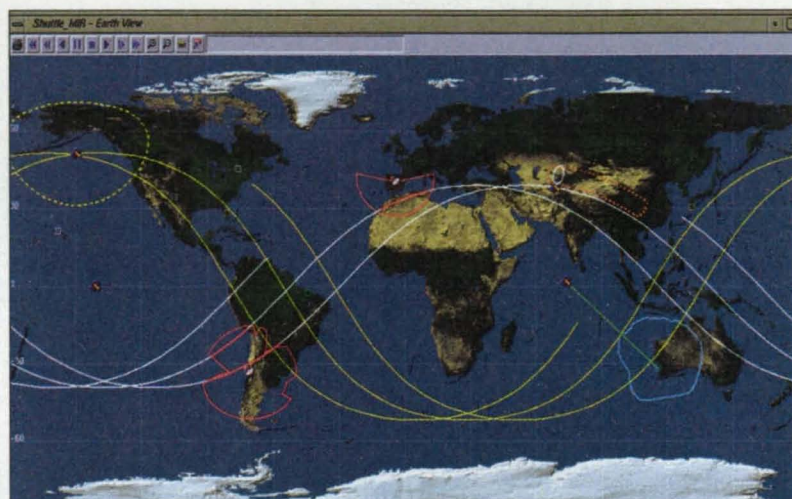
Analytical Graphics, Inc.
660 American Avenue
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Analytical Graphics, Inc.

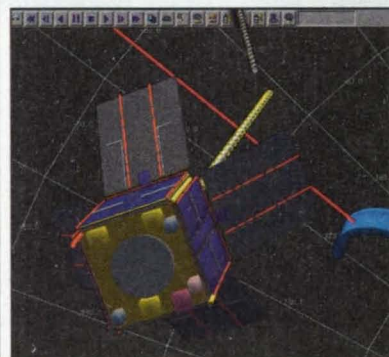
Satellite Tool Kit

As a fully integrated software suite, Satellite Tool Kit (STK)[®] provides the highest quality numerical and graphical analysis available,

ernment and military organizations in the United States and internationally, the foremost commercial aerospace corporations, and leading high-technology new businesses.



allowing users to stay ahead of the competition. The software rapidly analyzes and displays complex relationships among satellites, aircraft, launch vehicles, ships, ground vehicles, ground stations, and targets. Built by experienced analysts, STK enhances productivity, shortens schedules, and reduces costs.



Analysts, planners, systems operators, project leaders, and others in the aerospace industry benefit from STK's flexibility and ease of use. The software operates on both UNIX and Windows architecture, and a maintenance agreement allows users to port to another platform at any time. Users answer essential questions now, and those that arise throughout a mission.

What's more, STK's ongoing development and renowned customer support mean validated, verified, accurate analysis that has been proven effective during more than seven years of use by thousands of customers worldwide. The customer base includes gov-

Visualization Option & Programmer's Library

Satellite Tool Kit/Visualization Option (STK/VO)[™] is a fully integrated supplemental module for STK that provides a three-dimensional viewing capability. With this powerful tool, users gain an intuitive view of complex mission operation and orbit geometries. STK/VO displays satellites, facilities, targets, and sensors in a dynamic and realistic way. The result is state-of-the-art simulations and interactive performance on command.

STK also is available as a Programmer's Library (STK/PL)[™], a complete set of astrodynamics, graphic, and user interface functions that are tested, documented, and available for custom use. Developers can extend the scope and functionality of STK and its modules.

Other STK Modules:

- Chains[™]
- Close Approach Tool (CAT)
- Comm Module
- Inter-Process Communications (STK/IPC)[™]
- Precision Orbit Determination System (STK/PODS)[™]
- DAB Ascent[™]
- Generic, Resource, Event and Activity
- Scheduler (GREAS)[®]
- High Precision Orbit Propagator (HPOP)[™]
- Missile Flight Tool (MFT)[™]
- Navigator[™]
- SpaceVu[™]

Circle No. 809 On Fax Form



Nicholas Csendes, President and Chief Executive Officer

The past year has been witness to many exciting happenings at Ansoft Corporation. A new sales office in Europe, a successful Initial Public Offering, and record financial performance are only a few of the ways in which Ansoft has grown to become a strong leader in the electromagnetic EDA market.

Ansoft's technical leadership is a primary reason for our continued success. We continually seek to design and develop new technologies, products, and interfaces. Another reason underlying Ansoft's success has been the expansion of our direct sales, marketing, and customer support efforts in the U.S., Europe, and Japan.

Most recently, Ansoft announced the acquisition of the Electronics Business Unit (EBU) of the MacNeal-Schwendler Corporation, a major developer of computer-aided engineering software. This addition to our Ansoft family strengthens our position within the growing electromagnetics market through the integration of the talents and technological achievements of the EBU with Ansoft.

At Ansoft, we believe that real success is built over time by investing for the future. Ansoft will continue to invest in advancing our technological leadership and developing our existing markets. We will continue to invest in making Ansoft's staff pre-eminent in the industry, and we will continue to invest in making our customers successful.

Ansoft Corporation

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Company History

Ansoft has a history of creating significant technology breakthroughs. Zoltan Cendes, Ph.D., founder of Ansoft, conducted over 15 years of R&D prior to the company's inception in 1984. Since that time, over a decade of R&D by Ansoft research and development staff pioneered the notion of automatic and adaptive convergence to solutions, asymptotic waveform evaluation (AWE) for spectral domain solutions, transfinite elements, basis evaluation state space techniques, and fast multiple acceleration algorithms.



These advances meet the ever-growing needs of engineers as the market demands require smaller and faster devices with tighter design and compliance requirements. Ansoft continues to lead the technology in the industry with upgrades of its Maxwell products and the introduction of new products for both UNIX workstations and PCs.

Ansoft directly markets its products worldwide with a sales force and a network of distributors. Customers include leading electronics, telecommunications, and automotive companies including Motorola, Intel, Texas Instruments, Samsung, Hitachi, Sony, Sharp, Ericsson, SGS Thomson, GM, Ford, and BMW.

Products and Applications

Ansoft EM Product Line: Ansoft's first product, the Maxwell 2D Field Simulator, shipped in 1986. This analysis tool became the basis for the Maxwell EM product line. In 1990, Ansoft introduced the Maxwell 3D Field Simulator targeted at high-voltage, magnetic, power, biomedical, and electromechanical applications.

Ansoft's recent introduction of EMSS, Electromechanical System Simulator, demonstrates the continued commitment to provide cutting-edge technology to the CAE industry. EMSS offers a unique solution to the problem of predicting the transient behavior of electromechanical systems with moving parts. It enables the combination of electromagnetic device characteristics with equations of motion and circuit excitation to predict complete electromechanical system behavior.

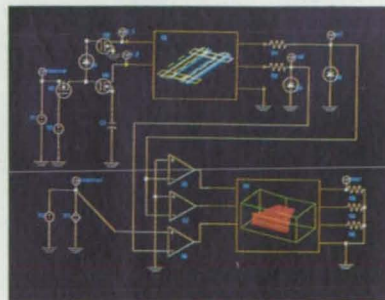
In 1994, Ansoft announced the redesign of its flagship EM product, the Maxwell 3D Field Simulator, offering major upgrades to solid modeling, pre- and post-processing, and mesh generation. This effort is in response to Ansoft's customers' requests and needs – again illustrating Ansoft's close relationship with its customer base and a commitment to customer satisfaction.

Ansoft High-Speed, High-Frequency Product Line: Ansoft entered the electronic design automation (EDA) arena in 1989 with the High Frequency Structure Simulator (HFSS), an Ansoft-developed product. HFSS is used by microwave component designers for defense and aerospace applications.

In 1992, Ansoft introduced Maxwell Spicelink, an electromagnetic extraction and signal integrity tool for analysis of high-speed digital interconnects, including semiconductor packaging, printed circuit boards, and die-level interconnects. Maxwell Spicelink was the first software product to combine four different extraction methods with a SPICE circuit simulator and multilayer interface to GDSII and DXF file formats.

Ansoft uniquely positioned itself in the signal integrity marketplace in January 1994 as the premier electromagnetic-based software tool vendor with the introduction of Maxwell Extractor and Maxwell Eminence. Eminence is the first commercial software product to offer an integrated solution to the full spectrum of high-speed design issues, from signal delays through electromagnetic compatibility. Eminence analyzes potential EMI/EMC problem areas, thus avoiding substantial redesign time and costs before a product leaves the design stage.

With the recent introduction of Maxwell Strata, Ansoft reinforces its presence in the high-frequency market. Microwave and RF designers benefit from Strata's true three-dimensional implementation of trace currents in highly dense planar PCB, MIC, and MMIC circuits.



Circle No. 815 On Fax Form



Concepts Engineering Education and Technology for Industry

Over the past 17 years, Concepts ETI, Inc. (CETI) has become the leading independent turbomachinery design and development organization in the world, providing state-of-the-art fully integrated engineering design software, turbomachinery design and development services, laboratory performance testing services, advanced technology development through SBIR and consortium programs, troubleshooting and design audit services, educational courses, and publications. CETI has a diverse staff of engineers with many years of experience in a broad range of turbomachinery applications. The CETI team can easily be integrated to work with your existing programs to address your turbomachinery needs for today and tomorrow.



Concepts ETI, Inc. Headquarters

Major emphasis at CETI is placed on developing advanced turbomachinery design, analysis, and test data reduction software for axial and centrifugal pumps, compressors, blowers, fans, turbines, and expanders. Highly interactive software allows an engineer to efficiently move from multi-point 1D design optimization through complete 3D CAD design, various 3D aero design (including 3D viscous CFD techniques), rotordynamic/bearing, and structural analysis, and directly into CAD/CAM. CETI is an agent and users' support provider for the FINE/TURBO CFD codes developed by NUMECA. CETI continues to support and use the BTOB3D

program. CETI's name continues to be synonymous with CFD validation.

CETI works with all aspects of turbomachinery for industrial and government clients. "Agile engineering" techniques and software are utilized for project work. Recent design/development and retrofit activities include projects for compact axial, mixed-flow, and compressor stages for missile applications; aircraft and industrial gas turbine stages; refrigeration compressors; industrial axial and centrifugal pumps; new radial inflow turbines; turbocharger compressors; unusually high

pressure

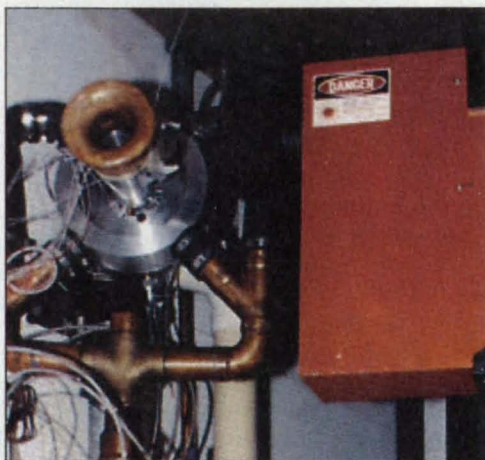
ratio; low specific speed process compressors; plant air compressors; large steam turbines; axial compressors and turbines; and rocket engine turbopumps.

Advanced technology development programs, through consortia, SBIR (government innovative research), and Internal

Research and Development, remain active at CETI. Four major consortium projects are in progress.

SBIR projects focused on improving SSME turbopump throttleability for NASA and increased stage loading for U.S. Air Force rocket turbopumps are underway. Other SBIR projects cover diffuser performance, innovative compressor cover bleed, engine health management, core cooling, and dynamic clearance control technologies for compressors and gas turbines.

CETI's laboratory capabilities are unique among independent design and development companies. Our laboratories contain instrumentation from classical pneumatic and thermal probes and traverses to more sophisticated hot-wire/hot-film and laser anemometers, high frequency pressure transducers, proximity probes, data acquisition systems, laboratory software, traversing equipment, and Polytec laser two-focus velocimeters. Our new Component Rotating Dynamics Laboratory (CRDL) magnetic bearing rig is

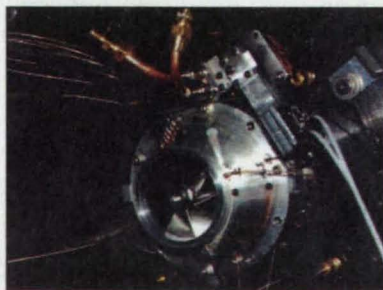


Laser velocimeter on test rig.

being used for the industrial pump consortium, rocket engine turbopump development testing, and compressor seal testing.

CETI's reputation has been built upon the strength of a comprehensive selection of turbomachinery courses for engineers. We have instructed over 2,500 students from 300 companies around the world. In 1997, over 12 courses will be conducted covering a broad range of turbomachinery topics. Students can earn credit towards a university master's degree for most of our courses. Please contact us for a 1997 schedule and a course catalog.

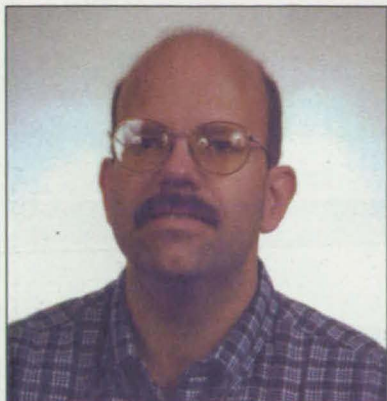
CETI remains at the forefront for turbomachinery publications. *Introduction to Turbomachinery and Centrifugal Compressor Design and Performance* were recently published. A comprehensive pump design book will be published in mid-1997.



G.T. compressor with comprehensive instrumentation.

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E-mail: ceti@valley.net

Circle No. 816 On Fax Form



Jeff Rankin
Director of Marketing

Analysis technology continues to advance at a rapid pace. It seems certain that future directions will focus on automating and speeding the calculations process. But many questions remain "left to the user." Loads, boundary conditions, materials properties, and interpretation of results are basic engineering questions that should be addressed long before any computer analysis is performed.

Companies that are successful with analysis tools often use it in two phases of the design process: 1) concept modeling and analysis before any detailed CAD takes place; and 2) validation of the detailed and final implementation.

In particular, the use of analysis tools before CAD provides a catalyst for design teams to address essential questions about different approaches. Concept modeling and analysis helps to eliminate bad designs early, and provides crucial insights into product performance. Validation of the final design provides a check that original concepts and assumptions were correct and provides feedback for future concept modeling.

Focusing on engineering fundamentals at both conceptual and validation phases of the process will improve the benefits derived from analysis.



FEMAP®

Enterprise Software Products

Products and Applications

FEMAP provides a consistent environment to enable technical professionals to quickly and efficiently develop simulations of mechanical product performance.

Geometry or finite element models can be created easily using bottom-up construction techniques popular for many conceptual modeling applications. As a complement, complex design geometry may be accessed directly from a number of popular CAD systems.

A powerful beam cross-section library is included. This library improves productivity by enabling you to automatically calculate area and inertial properties and provides visual feedback on beam orientation. A material library is included, which may be extended to meet company-specific applications. The finite element mesh can be developed using direct generation of elements, mapped meshing, or free meshing of surfaces and solids.

FEMAP is not a retrofit but rather a native and fully compliant Windows product. In the Windows 95 and Windows NT versions,

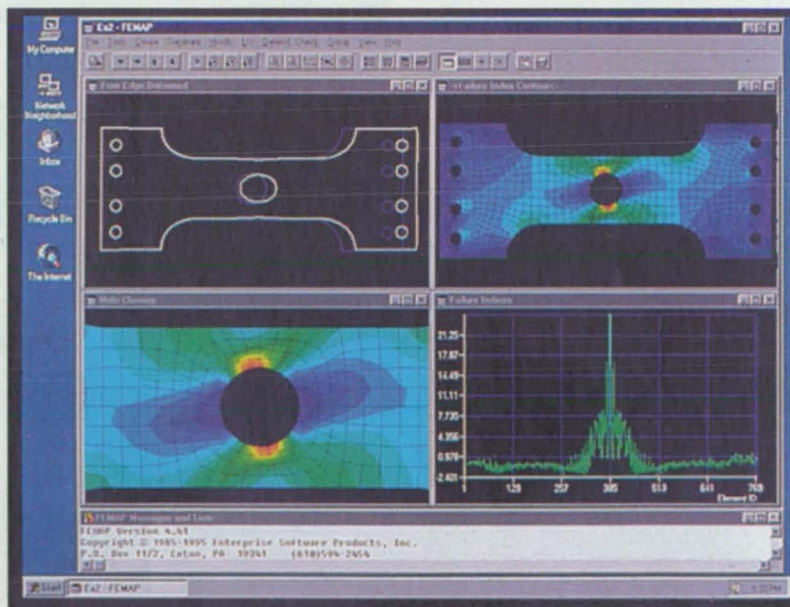
drag-and-drop and OLE 2.0 functionality is provided. FEMAP also is available on a number of popular UNIX workstations. Stress, deflection, temperature, heat flow, and dynamic performance can be solved by a wide range of commercial FEA solvers.

As application requirements change and as new solver technologies emerge, you easily can integrate these technologies while remaining in the FEMAP environment. FEMAP supports a very broad range of commercial FEA solver technologies, including many advanced features for ABAQUS, ANSYS, and MSC/NASTRAN.

Company History

Founded in 1986, the company continues to experience strong growth. As the use of personal computers for CAE has grown, so has the use of FEMAP. The firm also has partnerships with leading CAE providers including ANSYS, CSAR, MSC, and UAI.

Enterprise Software Products, and the FEMAP product line, are increasingly regarded as a companion to high-end FEA systems on workstations and supercomputers.



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Products, Inc.**
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www.femap.com

Circle No. 807 On Fax Form



INTEGRATED ENGINEERING SOFTWARE

The Company

Established in 1984, Integrated Engineering Software is a Canadian research and development corporation specializing in the development and marketing of fully integrated, graphical, Computer-Aided Engineering (CAE) 2D/3D software for electromagnetic and thermal design and analysis. All programs are based on the Boundary Element Method (BEM), now recognized as one of the most powerful and advanced field solution algorithms available. Programs provide research and development engineers in both large and small organizations with the means to optimize design, maximize efficiency, and reduce costs, allowing for the simulation and testing of a problem on the computer prior to actually building a costly prototype.

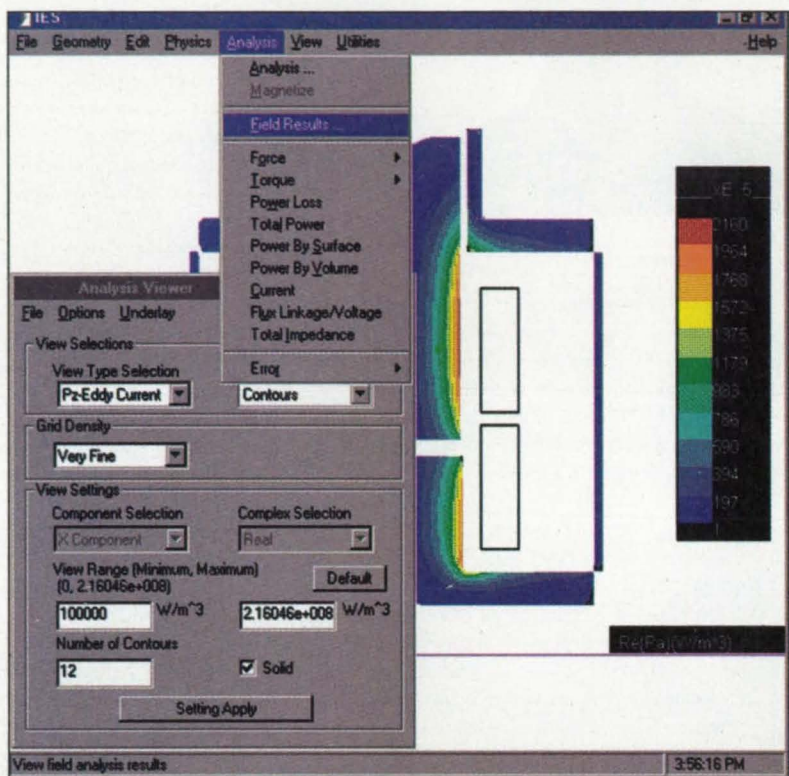
The Products

MAGNETO (2D/RS) and AMPERES (3D) are magnetostatic field solvers, while OERSTED (2D/RS) and FARADAY (3D) are low-frequency, time-harmonic field solvers. MAGNETO, AMPERES, FARADAY, and OERSTED are used for designing and analyzing a wide range of electromagnetic devices and components such as solenoids, AC/DC motors, transformers, recording heads, magnets and magnetizing fixtures, and cater to linear, non-linear, and permanent magnet materials.

ELECTRO (2D/RS) and COULOMB (3D) are electrostatic field solvers. ELECTRO and COULOMB are used in the design and analysis of electrical and electronic equipment such as insulators, bushings, grounding electrodes, transmission lines, telecommunication cables, and microstrip and integrated circuits.

KELVIN (2D/RS) is a heat transfer solver for equipment and components requiring thermal analysis such as electronic packaging, heat exchangers, and induction heating and hardening devices.

Using Integrated's CAE simulation software, designs are entered into the program, along with all the various material and design variables. A simulation is run and the results are presented. This way, the designers can "prototype" using a wider variety of variables

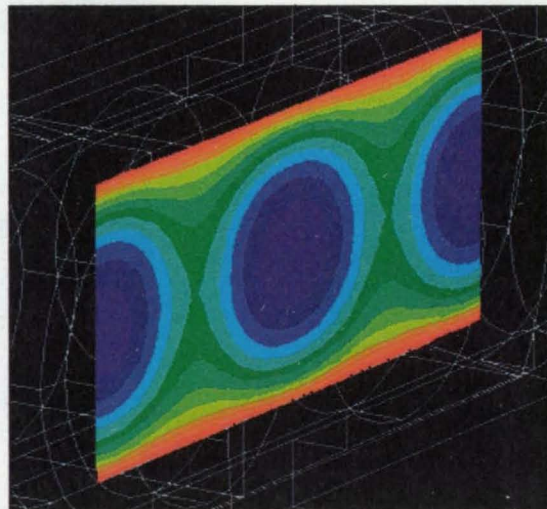


IES New Windows Interface

and materials, before having to physically build anything.

Integrated offers a 30-day No-Charge Evaluation of their full-version software, to allow potential customers to test program capability with no obligation to purchase.

All products are available to run under DOS, Windows, and a variety of workstation platforms. The 2D/RS suite of products has recently been released using a new-look Windows interface.



Electric Field Color Map for a focusing lens

**Integrated Engineering
Software**
Tel: 204-632-5636
Fax: 204-633-7780
E-mail: info@integrated.mb.ca

Circle No. 817 On Fax Form



Headquartered in Santa Clara, CA, Integrated Systems Inc. (NASDAQ: INTS) is the leading worldwide provider of embedded solution tools for the telecommunication, automotive, multimedia/consumer electronics, office/retail automation, aerospace, and process control industries. Founded in 1981, Integrated Systems' worldwide presence includes sales and services offices throughout Asia/Pacific, Europe, Canada, and the United States. The company has over 450 employees worldwide. Revenue for the 1996 fiscal year was \$84.4 million, an increase of 45 percent over the previous year's revenue.

Innovative, Unique Products and Services

The MATRIX_x® Product Family is the first fully automated system that allows for the graphical design, simulation, automatic code and document generation, and real-time test for real-time control systems. For over 10 years, the MATRIX_x Family has proven its value in numerous control and embedded systems engineering programs worldwide. Users include 26 of the world's top 28 automotive manufacturers, as well as the top aerospace, industrial process control, computer manufacturing, and research organizations.

The MATRIX_x product family features: SystemBuild™, the industry's leading graphical modeling and simulation environment; Xmath™, the first object-oriented mathematical analysis and visualization tool; AutoCode®, the first and most sophisticated automatic C and Ada code generator; DocumentIt™, the first automatic documentation generator; and the RealSim Series™ of rapid prototyping computers.

MATRIX_x Family

- End-to-end solution from concept to implementation
- Modeling, analysis, and simulation tools

pSOSystem Family

- Real-time embedded solutions

TakeFive

- SNIFF+—an integrated development environment for C/C++

Advanced Systems Group

- Custom designed software and systems integration

Dr. Design

- Custom designed real-time hardware and systems integration

The pSOSystem® provides a proven, full-featured run-time and development environment for real-time embedded applications. The pSOSystem consists of a family of development tools and embedded run-time technology that supports popular hosts and CPUs. There are three main parts of pSOS: the Runtime Core, which consists of a family of real-time, deterministic, multitasking kernels anchored by pSOS; and pSOS+m for multiprocessing solutions and pSOSselect for extremely small memory requirements. The Application Specific Solutions provide vertical market-specific solutions such as advanced networking and multimedia, and The Development Tools provides a complete set of integrated compilers, debuggers, and simulators tailored for embedded developers.

Positioned for Growth

In fiscal 1995, Integrated Systems significantly increased its share of telecommunications, data communications, and automotive embedded markets. The company acquired two new companies in fiscal 1996 that will further add to its host of products.

TakeFive Software, acquired in October 1995, provides solutions to aid in complex software development. Its SNIFF+ product is an interactive software development environment for C, C++, and other languages.

Doctor Design Inc., acquired in January 1996, is an engineering services company that specializes in applying state-of-the-art engineering technology to solve critical technical challenges for its customers.

Integrated Systems Inc.
Tel: 408-542-1500 or 800-770-3338
Fax: 408-542-1950
E-mail: mtx-info@isi.com
www.isi.com/webinar

Circle No. 826 On Fax Form

SPSS Plots a Scientific Future – Merger with Jandel Expands Scientific Offerings

Since the purchase of SYSTAT® in 1994 and BMDP in 1995, SPSS Inc. has been knocking on the door of the scientific community, offering its award-winning statistical solutions. That door swung wide open with the October 1996 announcement that SPSS was merging with Jandel Scientific. These three landmark acquisitions leave no room for doubt – SPSS is firmly entrenched as a supplier of solutions for scientists and engineers.

A Leader in Scientific Analysis Solutions

Founded in 1968, SPSS is a leading developer of desktop statistical product and service solutions. SPSS' first significant step toward meeting the data analysis needs of the scientific user began with the 1994 acquisition of SYSTAT, the award-winning statistical product for scientists.

SYSTAT is used by researchers who want fast, flexible statistics and graphics that speak the scientific language. The first version of SYSTAT was developed in the late 1970s by Leland Wilkinson, Ph.D., who has been and continues to be the guiding force behind SYSTAT's development.

As a pioneer in the desktop statistics software market, SYSTAT has received numerous awards for its quality and power, including *InfoWorld* "Best In Its Class" and "Buyers Assurance Seal," *PC Magazine* "Editor's Choice" award, and a top rating in the *PC Week* "Corporate Satisfaction Poll." Following this strong tradition, SYSTAT 6.0 for

Windows sets a new benchmark, attaining new levels of user friendliness, interactive data exploration, and robust statistical analysis. It is the tool the serious researcher can rely on from data to discovery.

The Plot Thickens

By strengthening its scientific offerings through the purchase of Jandel Scientific, SPSS expands its offering of state-of-the-art software tools for scientific research. Most notable is SigmaPlot®, the leading brand of scientific graphics software. SigmaPlot features extraordinary control, powerful data analysis, and an extensive range of scientific options. With an installed base of over 100,000 users, SigmaPlot is used more than any other software product by scientists to

and Automation "Reader's Choice" award five years in a row. In addition, SigmaPlot was named in the September 1996 *Desktop Engineering* "Author's Choice Awards," with the reviewer proclaiming, "When it comes to choosing the program that will best meet the needs of the bulk of scientific and engineering users, it isn't close: it's SigmaPlot by a mile."

Jandel's other products, including SigmaStat®, SigmaScan™, Tablecurve™ 2D and 3D, PeakFit™, and SigmaGel™ round out SPSS' new product offerings.

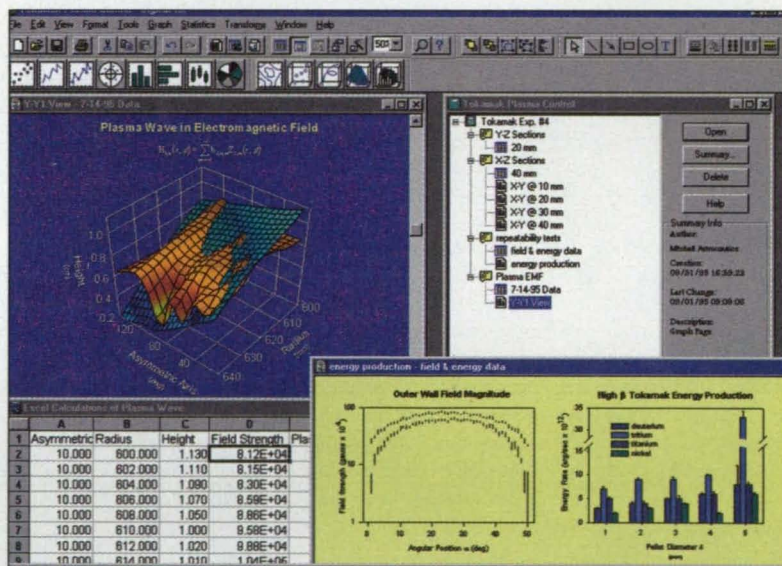
Delivering the Future

SPSS' considerable resources assure that the entire line of scientific analysis tools is available worldwide. SPSS boasts an extensive worldwide distribution network,

including 27 offices and more than 60 distributors around the globe. This extensive overseas distribution guarantees that all of the SPSS scientific product offerings will be readily available to scientists throughout the world.

Whether in the U.S. or abroad, SPSS is clearly demonstrating its commitment to provide comprehensive data analysis solutions to the scientific community.

This commitment ensures technologically advanced products, aggressive product development schedules, expert technical support, and responsive distribution channels.

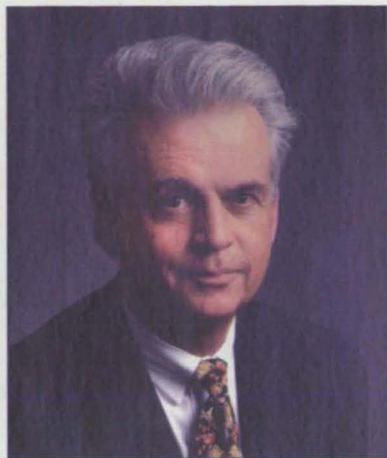


prepare their graphs for publication.

Jandel's products have earned industry-wide acclaim from reviewers and customers alike, SigmaPlot was awarded a *PC Magazine* "Editor's Choice," and SigmaPlot has consistently won the covered *Scientific Computing*

Jandel Scientific
Tel: 415-453-6700, ext. 248

Circle No. 818 On Fax Form



Thomas C. Curry, President & Chief Executive Officer

MSC's mission is to provide software tools and related services (solutions) to global manufacturers worldwide, and to improve their design-to-manufacturing process (faster to market, improved quality, less cost). We offer complete solutions (software and services) to complex structural problems through our direct sales channel, packaged products via resellers, and component technology through our OEM partners. Our solutions offer the highest value available, and solve the widest range of the most difficult problems on any platform, faster and more reliably than our competition.

MSC's goal is to keep pace with our customers' changing design-to-manufacturing processes by changing our orientation from technology-driven to customer-driven, replacing our emphasis on providing FEA software products with complete computer-aided engineering solutions. By doing this, we become strategic partners with our customers and directly contribute to their success.

A key component in our goal to move closer to our customers is our formation of market oriented business units – aerospace and defense, automotive, and growth industries. These business units are staffed with development, marketing, and sales personnel who have both CAE software expertise and technical backgrounds in their respective industries.

We are already discovering that this approach is a turning point in our history and we are convinced that both MSC and our customers will benefit from this approach.

The MacNeal-Schwendler Corporation
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Los Angeles, CA 90041
Tel: 800-336-4858
Fax: 213-259-3838
www.macsch.com



**The
MacNeal-Schwendler
Corporation**

MSC/NASTRAN Version 69 & MSC/PATRAN Version 6

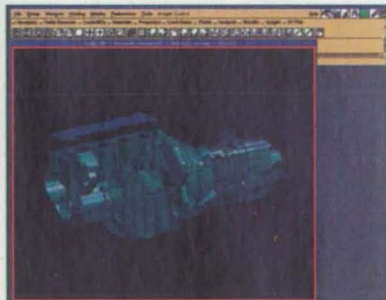
New Features and Enhancements

For the first time, new releases of MSC/NASTRAN and MSC/PATRAN are being shipped simultaneously to customers, offering substantial product enhancements and increased performance, accuracy, and quality to engineers.

The focus of MSC/NASTRAN Version 69 and MSC/PATRAN Version 6 has been on CAE modeling and performance improvements for automotive and aerospace companies. Version 69 of MSC/NASTRAN focuses on improving engineering throughput, with significant enhancements to both the program's raw performance and its ability to handle large and complex problems. Over 100 user-requested enhancements have been incorporated into this latest version. Version 69 includes a world-class solver that uses significantly less memory and disk space than other products in the CAE industry.

Improved integration and increased modeling capabilities have been the main goals in developing the latest version of MSC/PATRAN. The most significant enhancement in Version 6 is the incorporation of the Parasolid geometry modeling kernel into MSC/PATRAN. Parasolid also is the solids modeler at the core of EDS/Unigraphics.

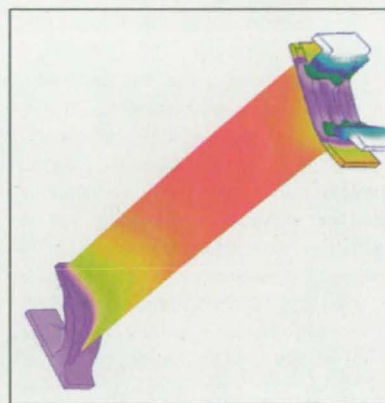
The newest version allows customers to import their solid Unigraphics (UG) CAD



parts directly into MSC/PATRAN to create analysis models with absolutely no translation or approximation. Customers using both MSC/PATRAN and Unigraphics will realize a tremendous throughput improve-

ment in the import of UG parts into MSC/PATRAN, and the subsequent creation of finite element models.

The integration of the transfer of data between MSC/PATRAN and MSC/NASTRAN has also been greatly improved in this release of MSC/PATRAN. This increased level of integration, as evidenced by enhancements such as the ability to transfer beam properties and heat transfer data, provides an unparalleled suite of analysis capabilities.



Company History

The MacNeal-Schwendler Corporation is the world's largest provider of computer-aided engineering solutions. MSC's solutions are built on an unmatched foundation of engineering expertise, technology leadership, and superior customer support. Its strength as a company is its ability to anticipate the engineering needs of MSC customers, identify their requirements, tailor software products to those needs, and then follow up with strong user support.

From its inception on February 1, 1963, when Dr. Richard H. MacNeal and Robert G. Schwendler founded MSC with an \$18,000 investment, engineering excellence has been a hallmark of the company. The firm's primary analysis software spans the development of computer hardware over three decades, providing MSC with unique insight and a corporate finger on the pulse of high technology.

Circle No. 823 On Fax Form



Charles J. Digate, Chairman, President & CEO

MathSoft is the leading provider of knowledge discovery software. Founded in 1984, MathSoft users include technical professionals worldwide at more than half the Fortune 1000 companies and over 500 government installations, scientists, researchers, and students and faculty at over 2,000 colleges and universities.

MathSoft's products include the award-winning Mathcad® and Axum®, numerous electronic books, S-PLUS® and Study-Works®. MathSoft distributes its products through third party resellers, including retail and software stores, catalogs, college bookstores, value-added resellers, and publishers. All MathSoft products are available by contacting MathSoft directly.

Recently, MathSoft opened an on-line math, science, and engineering web store for software and electronic books (<http://www.mathsoft.com>). Here, interested parties can obtain detailed information on MathSoft's products using an on-line catalog. Consumers are able to download the software directly or test the products before purchasing.

MathSoft is publicly traded on the NASDAQ National Market System under the symbol MATH.

MathSoft, Inc.
101 Main Street
Cambridge, MA 02142
Tel: 617-577-1017
www.mathsoft.com

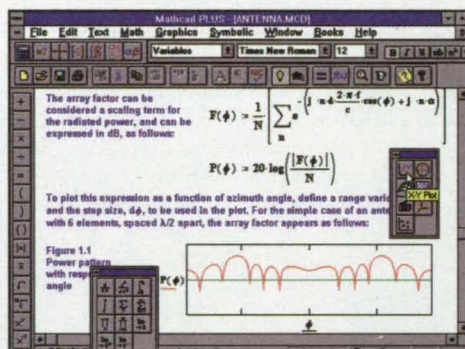
MathSoft

$\Sigma + \sqrt{-} = \times \int \div \delta$

Products and Applications

• The Mathcad Technical Professional Suite™

The Mathcad Technical Professional Suite, consisting of Mathcad PLUS 6.0, Visio Express® for Mathcad, the new Axum 5.0, and the Mathcad PLUS 6.0 Treasury, is an extensive package of productivity tools. It was created for use by operators who regularly perform mathematical calculations, develop engineering models, or create technical procedure reports. The Mathcad Technical Professional Suite is designed to assist engineers, scientists, statisticians, and other technical professionals to create and manage technical documents from start to finish using a suite of integrated productivity tools.



The Mathcad Technical Professional Suite is available for single users and workgroups (5-seat, 10-seat, 25-seat). It runs on Windows 3.1x or NT running on an 80486 or higher (coprocessor recommended), mouse, Windows-compatible video, 3.5" disk drive, 50 MB disk, minimum of 16 MB memory with swap space. The single-user license is available for \$495. For more information, contact MathSoft directly or visit the MathSoft Web Site at <http://www.mathsoft.com>.

• Mathcad

MathSoft's flagship product, Mathcad, is the most widely used technical calculation software worldwide. Today, there are more than one million users of Mathcad.

Mathcad PLUS 6.0 is a powerful, easy-to-use, integrated technical calculation product for Windows 95, Windows NT, and Windows 3.1x. Mathcad consists of an extensive set of numeric and symbolic mathematical and data analysis features, 2D and 3D graphing and visualization capabilities, and tools for collaboration including built-in Internet connectivity. Mathcad PLUS 6.0 pro-

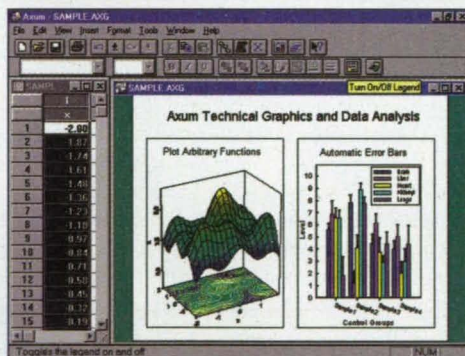
vides users with a live, interactive environment for solving real-world problems and documenting the results. The combination of Mathcad PLUS 6.0 and Visio Express allows users to create technical drawings by dragging and dropping Visio SmartShapes® from the software's wide range of electronic stencils.

• Axum

Award-winning Axum is a powerful and flexible technical charting and data visualization package. There are over 10,000 registered users of Axum worldwide.

New Axum 5.0 is available for Windows 95, Windows NT, and Windows 3.1x. Axum combines the ease of use of the best-selling PC

business graphics package with powerful features such as 80 2D and 3D technical plot types, 3D contour plotting, linear and nonlinear curve-fitting, and new multipanel plots™ to help reveal data patterns you can't see using traditional techniques. Axum lets you combine multiple, editable graphs on a page and customize every detail. Its slick interface makes it easy to learn and use. Fully interactive, elements from Axum 5.0 can be embedded in Mathcad work-

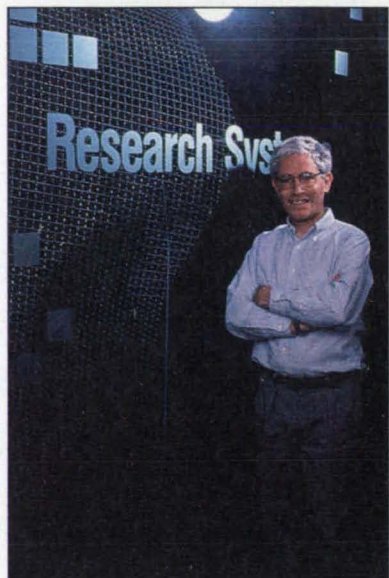


sheets, providing users with an integrated backdrop for the creation of publication-quality projects.

• The Mathcad PLUS 6.0 Treasury

Working with Mathcad PLUS 6.0, The Mathcad PLUS 6.0 Treasury provides fully interactive examples of all of Mathcad's mathematical features. The Treasury works seamlessly with Mathcad, allowing the user to drag and drop live formulas into existing Mathcad worksheets. Tips and explanations found in The Treasury help the user to maximize the benefits of Mathcad PLUS 6.0.

Circle No. 819 On Fax Form



David Stern, President

Research Systems' corporate motto is Software=Vision. Our goal is to create software that is visionary, both in the sense that the software embodies extraordinary vision and foresight, and that it gives our customers the vision to clearly see and understand their data.

My focus as president of Research Systems is to lead our growing team in the creation of software that is perfect in every aspect. Although our goal is unattainable, we nevertheless constantly strive to make our software more accurate and powerful, faster, and easier to use.

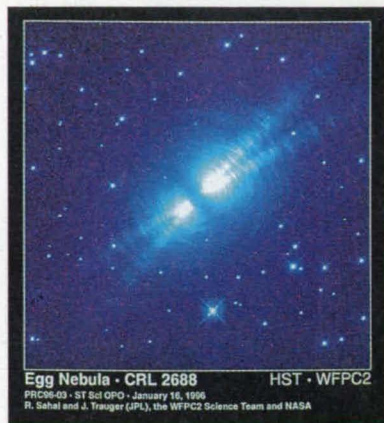
We have more than doubled the size of our engineering staff during the past year. We have invested in people with the expertise required to design and implement software in today's rapidly changing world of technical computing. Top-notch engineers skilled in science, mathematics, user interface design, and the wide variety of computing platforms are working to improve our present products and create exceptional new products. We are continually improving the ease-of-use of our software to make your work more enjoyable and productive. We've also added a full-time test engineer to ensure that each release of our software is more reliable than the last.

Research Systems, Inc.
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www.rsinc.com

Research Systems, Inc.

Products and Applications

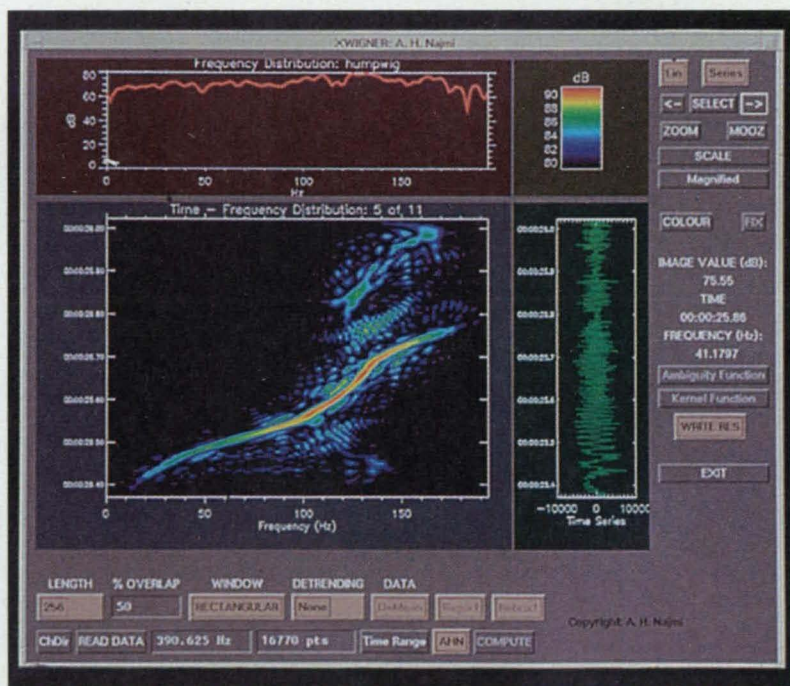
IDL®: Interactive Data Language. Immediately gain insight from your data with IDL®, the ideal software for data analysis, visualization, and application development. Reduce your development time with IDL's high-level, array-oriented programming language and interactive library of 2D and 3D graphics, mathematics, statistics, and cross-platform GUI tools. IDL also includes advanced image processing, volume visualization, flexible data I/O, and versatile program linking tools. One or two lines of IDL code can do the job of several hundred lines of C or Fortran. IDL programs are portable across Windows 3.1/95/NT, UNIX, Linux, Macintosh/PowerMac, and VMS platforms. If you analyze data from tests, experiments, simulations, or images, or write applications for others to use, IDL will help you get clear results faster.



Egg Nebula - CRL 2688 HST - WFPC2
 PR096-03 - ST ScI OPO - January 16, 1996
 R. Sahai and J. Trauger (JPL), the WFPC2 Science Team and NASA

mer every time they needed to write or modify an application. Research Systems, Inc. and IDL, the Interactive Data Language, were born from that prototype.

During the early 1980s, Stern realized that

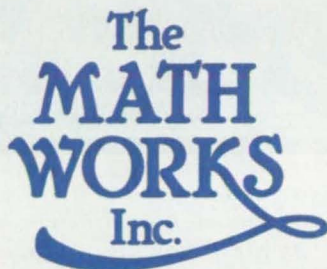


Company History

In 1977, David Stern was working at the University of Colorado with a team of scientists interpreting the data from the Mariner Mars 7 & 9 space probes. While there, he wrote the Mariner Mars Spectral Editor (an IDL® prototype), a software language that went beyond the functionality of Fortran and provided for easier, faster application development, data analysis, and visualization. It successfully allowed scientists to test hypotheses without employing a program-

doctors, engineers, and earth scientists required data analysis and visualization techniques to keep up with the explosion of data produced by modern instruments. IDL was rewritten to specifically address the problem of handling large amounts of data. Consequently, IDL has played a critical role in virtually every NASA and European Space Agency mission since that time.

Circle No. 830 On Fax Form



The MathWorks, Inc.

Company History

The MathWorks, Inc., located in Natick, MA, was established in December 1984 by Cleve Moler and John Little to develop and market interactive engineering and scientific software products. As founders of The MathWorks, Moler and Little recognized the need among engineers and scientists for more powerful computing environments beyond those represented by Fortran and C. In response to that need, they combined their expertise in mathematics, engineering, and computer science to develop the MATLAB® software product, an interactive system that provides high-performance numeric computation and graphics in an easy-to-use environment. The MathWorks employs over 350 people and its products are in use by more than 300,000 technical professionals in over 100 countries.

Products and Applications

MATLAB is a high-performance technical computing environment that provides comprehensive math and graphics, specialized application toolboxes, and a powerful structured programming language. MATLAB offers hundreds of convenient, built-in functions that users can customize and extend as needed. Users can also link in their existing C and Fortran programs. The new MATLAB Compiler and C Math Library allow users to automatically convert their MATLAB pro-

grams into portable C code for standalone applications that run outside of the MATLAB environment. MATLAB files and user-written applications are portable across PC, Macintosh, and UNIX workstation platforms.

SIMULINK®, built on the MATLAB technical computing environment, is an interactive system for analyzing, modeling, and simulating dynamic nonlinear systems. Real-Time Workshop™ extends SIMULINK for generating real-time code for embedded control, hardware in-the-loop, and rapid prototyping. Generated code can be applied to many applications, and the open architecture promotes a multitude of solutions for real-time applications. Hardware interfaces are available for prototyping of control systems and digital signal processing applications. For control system prototyping, dSPACE provides turnkey support based on DEC Alpha or Texas Instruments DSP hardware. Similarly, digital signal processing applications are supported on hardware offered by Loughborough Sound Images, Ltd.

MATLAB Toolboxes and SIMULINK Blocksets extend the power of MATLAB by providing algorithms and functions developed by experts in digital signal processing, control system design, image processing, symbolic math, finance, statistics, neural networks, system identification, optimization, and other application areas.

The MathWorks, Inc.
24 Prime Park Way
Natick, MA 01760
Tel: 508-647-7000
Fax: 508-647-7101
E-mail: info@mathworks.com
www.mathworks.com

Circle No. 820 On Fax Form



Variation Systems Analysis, Inc. (VSA) was formed in 1981 to provide our client base with computer software tools and engineering methodologies to improve the competitive position of their products through controlled variation and robust design. Our focus has been on developing the software tools and engineering expertise to support the implementation of a structured Dimensional Management Process in large engineering, manufacturing, and product assembly organizations. The Dimensional Management Process centers on integrating the following six key ingredients for dimensional quality into your product release cycle through well-defined deliverables.

- All product dimensional requirements are clearly defined at the beginning of the design cycle.
- The design, manufacturing, and assembly process as specified optimally meets product requirements.
- Product documentation is correct and communicated effectively throughout the

product team (i.e., GD&T, nominal geometry, assembly locators, SPC checkpoints, assembly methods, and process).

- A measurement plan is implemented that validates product requirements.
- Manufacturing capabilities achieve design intent.
- A well-defined production-to-design "feedback loop" exists.

The engineering consulting expertise that VSA has gained through the application of our products on thousands of real-life examples and the direct integration of our Dimensional Management software products with the leading CAE software vendors has allowed us to become the world leader in Dimensional Management.

Our 3-Dimensional tolerance analysis software tools are integrated with many CAE systems as described below:

VSA-GDT is a tolerance checker and Geometric Dimensioning and Tolerancing (GD&T) analysis software program directly integrated with many popular CAE systems. VSA-GDT analyzes the GD&T scheme to

determine if it is correct according to the ANSI/ISO Standard. The software verifies that each feature is correctly constrained in form, orientation, location, and size. It also ensures that the feature control frames are syntactically correct, and each feature is related to the master datum reference frame through one unique path.

VSA-3D is a 3-dimensional tolerance analysis software program using statistical simulation techniques to predict the amount of variation that can occur in an assembly due to specified design tolerances, fixturing tolerances, and manufacturing/assembly variation. Additionally, VSA-3D can determine the contributing factors of the predicted variation and their percentage of contribution. VSA-3D is directly integrated with many popular CAE packages.

If your organization is interested in learning more about how the Dimensional Management Process, combined with our software tools, might help you improve the quality and competitive position of your products in the marketplace, please call one of our facilities.

Variation Systems Analysis, Inc.
300 Maple Park Blvd.
St. Clair Shores, MI 48081
Tel: 810-774-2640
Fax: 810-778-6470
E-mail: info@vsa.com

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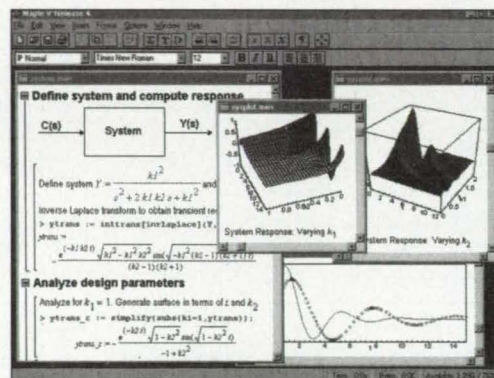
Beyond Numerical Solvers: Application of Symbolic Mathematical Software in Modeling and Simulation

Traditionally, the role of computers in modeling and simulation has been that of solvers. Sophisticated numerical algorithms have been developed to solve models consisting of a wide range of mathematical constructs. Any numerical approach, however, has three fundamental disadvantages:

- All parameters must be known for solution, resulting in guess-work and excessive simulation runs to identify optimal parameter values.
- They have inherent errors due to the substitution of exact model information with approximations.
- They address only the solution phase. Modeling is a more complex task and often the most time is spent on the formulation of models and interrogation of results.

Maple V, an integrated symbolic mathematical processing system, addresses the shortcomings of conventional software by providing computing support for all phases of modeling and simulation.

Model Formulation: Maple V's symbolic manipulation replaces the error-prone manual development of models. Its functions in calculus, algebra, tensors, statistics, and others allow users to automate many formulation methods. Derivation of equations of motion through Lagrangian formulation, or control system transfer functions, are examples where Maple can save days over



symbolic forms of parameters. You also can apply semi-numerical algorithms that are approximations of solutions but maintain the parameters in variable form. Examples include perturbation techniques and Galerkin methods for partial differential equations.

Model Optimization: The mathematical facilities offers facilities to compute necessary components of formal optimization (e.g., computation of symbolic Jacobians). Maple V's unique interface for interactive problem-solving and mathematical visualization provides a convenient environment to fully analyze model solutions.

Application Development: A true programming language streamlined for mathematical applications supports the above facilities. Advanced mathematical applications can be programmed in a fraction of the time that it would take with other languages. You can quickly develop an array of customized tools that can effectively deal with difficult model constructs such as non-linearities or stochastic elements. Consequently, Maple V provides an extremely cost-effective alternative to expensive simulation and design software.

For more complete discussion on the application of Maple V in advanced technical modeling, contact Waterloo Maple Inc. and request a copy of "Surpassing the Limits of Technical Computation."



conventional work. In addition, optimized FORTRAN and C code generation offers the easiest way to link modern symbolic modeling techniques to legacy code and solvers.

Model Solution: Maple V can compute exact, closed-form solutions that maintain

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www.maplesoft.com

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PRECISION FILTERS

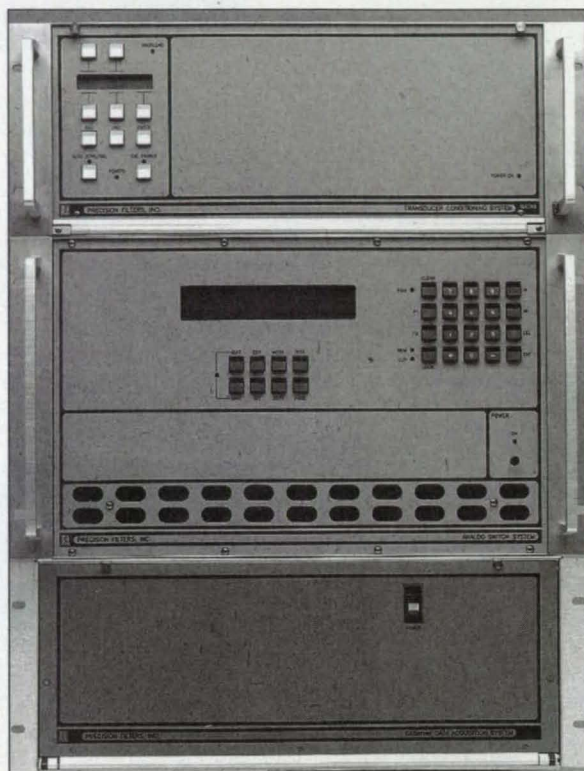
CONDITIONERS • SWITCHES • DATA ACQUISITION • SYSTEMS

At the time of incorporation in 1975, Precision Filters' charter was to design and manufacture signal conditioning systems. Our product line has since evolved by responding to customers' evolving needs: more functions, improved performance, and simplified control, while decreasing space and cost.

You will find Precision Filters' equipment in use in scientific and industrial laboratories, on ship-board, and in aircraft around the world. We have developed acoustic receivers for bathymetric systems, utilized frequency-band translation technology for enhanced signal analysis, and developed super-matched programmable filters for magnetic resonance imaging applications.

We now offer integrated high-performance signal conditioning, switching, data acquisition, and data recording "front ends" for test and measurement systems and active control systems. In addition, Precision Filters also offers a diverse range of board-level products and custom signal conditioning products for the OEM market. We have recently responded to customer requirements with a family of filters, amplifiers, and frequency translators for the VMEbus. The high-density cards allow high-channel-count signal conditioning systems to be implemented in a few available VMEbus main-frame slots.

We are always interested in hearing your special needs. Chances are we already have a system we can customize to your needs with standard hardware. We invite you to contact



This integrated data acquisition system features signal conditioning, switching, and data conversion.

Precision Filters and let us put our expertise to work creating a custom solution for you.

Transducer Conditioners

The Precision 27000A Series is a family of universal signal conditioners suitable for use as standalone or remote test systems. The Precision 27000A can be tailored for high-speed transient applications, static applications, or a combination of both. Up to 128 channels in a 7" mainframe. Mix transducer conditioners to meet your requirements: resistive bridge, voltage (filter/amps), ther-

mocouple, RTD, potentiometer, charge, and current.

A graphical user interface simplifies setup and operation. Self-test and verification with end-to-end calibration is supported.

Switching Systems

To help customers manage the hundreds, even thousands, of channels needed in today's test facilities, we introduced the Precision Programmable Patch system. This system allows signals to be connected, changed, and verified all in a few minutes.

The Programmable Patch offers computer control for faster, more accurate set-ups of complex tests. A test subsystem provides go/no-go verification and diagnostics, allowing problem correction before running costly tests.

Using standard hardware, the Programmable Patch is customized to the user's needs. Both solid state and reed relay matrix systems are available, as are reed relay bank switches.

Data Acquisition

The Precision 8600 DAsServer family of Data Acquisition and Recording Systems combines high-performance A/D conversion and high channel density with integral large capacity mass data storage and full networking capability that complies with industry standard networks, protocols, and user interfaces.

Select from a wide range of 12-bit and 16-bit A-to-D digitizer modules. System platforms based on the industry-standard 6U VMEbus accommodate up to 512 simultaneously sampled input channels.

Precision Filters, Inc.
240 Cherry Street
Ithaca, NY 14850
Tel: 607-277-3550
Fax: 607-277-4466
E-mail: pfinfo@pfinc.com

Circle No. 802 On Fax Form

RACAL

Communicating through technology

Products and Applications

Racal-Heim blends the best of Heim technology – superior signal front ends and airborne packaging – with the best of Racal technology – the high data rate, recording duration, and large portable IRIG configuration of Racal's recorders.



The Storeplex portable instrumentation recorder is a lightweight, modular, digital recorder that utilizes S-VHS cassette tapes for efficient and reliable data recording. The Storeplex recorder features remote control operation, up to 64-channel capacity, 96 dB dynamic range via 16-bit analog-to-digital signal conversion, up to 68-Gbit data storage capacity, and a 2.5-MHz channel. Storeplex also features two graphical user interfaces (GUIs) for automated remote control and rapid tape-to-disk data transfer.

The Storehorse, which incorporates double-density record and replay heads, is designed for use by non-specialists such as researchers, development engineers, and intelligence gatherers whose primary

requirement is accurate data collection. Storehorse is compatible with both IRIG (Interrange Instrument Group) and ISO (International Standards Organization) standards.

The Storehorse DD-4 (double-density, 4 MHz) instrumentation recorder adds 4-MHz performance at 120 in/s and can record up to 28 channels, providing extended data capture for applications such as frequency down conversion, sonar, and radar recording.

DATaRec A40, A60, A80, and A160 Digital Recording Systems are analog input, 2-64 channel digital recording systems, which have built-in interchangeable signal conditioning for microphone, charge, strain gauge, and ICP transducers. Speed and RPM inputs/outputs, and SCSI computer output and control are standard.

DATaRec D4 is a 4-

Mbit/s digital tape recording system with five free slots for PCM, 4-channel PCM, MIL-STD-1553 bus, ARINC 429 bus, and 8-channel analog input/output interfaces, and is ruggedized for airborne and military vehicle use.

The DATaRec D12 recorder uses DLT technology to provide hours of continuous recording at a data rate of 12 Mbit/s. The D12 can record any of a wide range of input signal types – serial and PCM data, ARINC 429 bus data, MIL-STD-1553, and analog –

thus ensuring compatibility with the widest range of signal sources without the need for any external electronics.

Company History

Racal Recorders, Inc., Irvine, CA, the professional recorder company, is a subsidiary of The Racal Corporation, based in Sunrise, FL. For more than 45 years, Racal Recorders has produced advanced, large-capacity voice (communications, surveillance) and data (instrumentation, data acquisition) recording systems.

Racal Recorders markets the complete line of instrumentation from Racal-Heim GmbH, a new company formed recently when U.K.-based Racal Recorders Limited acquired Josef Heim KG, Cologne, Germany, the leading European instrumentation recording company.

The formation of Racal-Heim merged the two leading names in instrumentation recording worldwide, bringing together compatible lines of instrumentation products that meet the widest needs for data acquisition and recording systems in automotive, defense, aerospace, and industrial applications.



Racal Recorders Inc.
15375 Barranca Parkway
Ste. H101
Irvine, CA 92718

Circle No. 806 On Fax Form



H. Yamaguchi, President

As we enter the 21st century, vast R&D aimed at improving society and the quality of our lives is being conducted in the natural sciences, space exploration, automotive, and aerospace. Accurate recording and recall of the incredible quantities of data that support such research efforts constitute the basic performance capabilities of the digital data recorder. Along with precise playback of recorded data, the reliability of the device's ultimate measurement and data processing functions is equally critical. Stable performance and constant operating characteristics are absolute prerequisites in this regard.

Finally, the test of a good product is one that feels good to people who are using it. User-friendly controls, portability, and processing ease are essential. TEAC is a recognized leader in product development in this field. And we believe that the field of measuring instruments holds limitless possibilities for the future.

TEAC America, Inc.
7733 Telegraph Road
Montebello, CA 90640

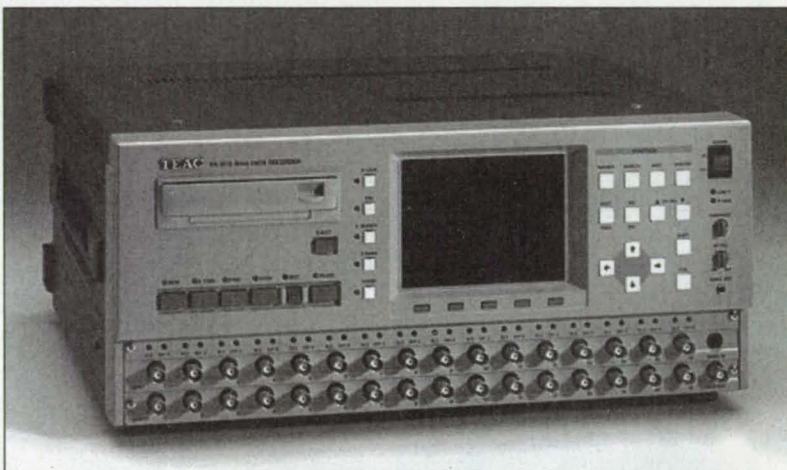
TEAC America

Products and Applications

From its foundation in 1953, TEAC has established an unrivaled position of leadership in technical innovation, with specific expertise in magnetic recording technology.

tape, Digital Audio Tape (DAT), and Hi8mm Video cassette tape.

Products are available for virtually all conceivable applications: lightweight, compact units; those with long, continuous recording



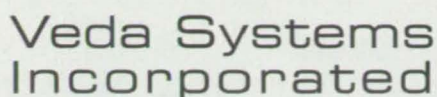
Today, TEAC manufactures and sells around the world a wide range of magnetic tape and optical recording equipment, from measuring instruments and computer peripherals through video and videodisc equipment, to professional and general audio components.

Since developing Japan's first instrumentation data recorder in 1956, TEAC has created a product lineup unrivaled by any other single manufacturer, and that uses the full range of available media: open-reel tape, compact cassette tape, VHS videocassette

times; and others with a host of special functions.

TEAC data acquisition systems already are at work in the widest possible range of applications. They are used to record shock-vibrations in the civil engineering and construction industries; to record natural phenomena in environmental and pollution measurements; the acquisition of meteorological and seismological data; and in physiological studies and electromyographic data.

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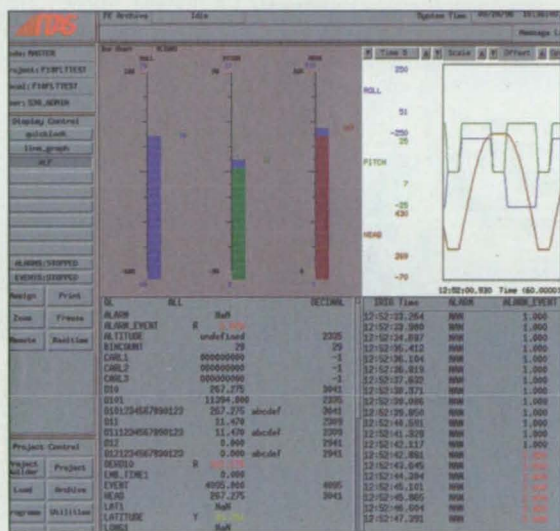
OMEGA Software Toolkit

OMEGA Toolkit acquires data from a wide variety of archived and real-time sources.

truly open, highly adaptable hardware configuration. Hardware is configurable on a modular basis, including PCM, 1553, ARINC-429, CCSDS, and NASCOM. Capabilities include intelligent multiplexing (IMUX), which provides a straightforward digital multiplexing front end for advanced digital tape recorders or for data transmission networks. With the inclusion of IMUX, the user can acquire multiple signal types, multiplex them into a single serial stream, and format them into a single digital stream for transmission and recording. Any or all inputs may be selectively directed to multiple digital tape recorders or transmitters.

Customize or enhance existing telemetry systems by choosing from Veda Systems' line of board-level modules. Modules are available with drivers or full systems software, and are available in PCI, VME, and ISA versions.

Whether it's fully integrated systems or board-level products, Veda Systems provides the finest quality engineering and the most dependable telemetry systems for existing and future data acquisition needs.



ly integrated with specialized software to meet individual project requirements.

ITAS Series-30 System

The ITAS Series-30 System is a fully integrated hardware and software package for your data acquisition requirements. The system features the highly lauded OMEGA software, with its data-driven frame synchronization, deconvolution, EU processing, archive, 2- and 3-D display functions in a



Data Acquisition

Veda Systems Inc.
44417 Pecan Court
California, MD 20619
Tel: 301-737-1555
Fax: 301-737-1564
E-mail: sales.vsys@veda.com
www.vedasystems.com

Circle No. 803 On Fax Form



Kunio Minejima, President

Graphtec Corporation was one of the first global instrument companies to establish an American subsidiary, Western Graphtec, Inc., to be more responsive to American markets. We are renowned for our quality of service and for the manner in which our marketing engineers and software engineers cooperate to benefit entire industries.

Because the massive amounts of remote scientific data being collected by customers are beginning to exceed the practical file sizes for an Ethernet or LAN to transmit, or for a PC to archive, screen, and analyze, we are concentrating on interrogating the stored data and transferring only that which is pertinent. Since only a small portion of data is normally useful, why waste time and expense to transfer massive files?

For example, our DMS1000 Data Management System, designed and manufactured in Irvine, CA, can provide the screening and analysis functions previously performed by a PC, while archiving up to 16 gigabytes of raw data, which is more than eight times larger than what a PC can handle.

We will continue to serve high-technology industries with the most powerful and cost-effective data acquisition and diagnostics systems.

New Advancements in Data Acquisition and Diagnostics

With microcomputers having changed the instrumentation world from one that was hardware-driven to one that is software-driven, we live in a new era of software solutions in which "it can't be done" is an unacceptable response to most customer requests.

powerful search-and-evaluate routines for retrieving and analyzing pertinent data. Total cost per channel can be as low as \$1000.

The WR9000 Data Acquisition and Diagnostics System introduced in 1996 is a portable flatbed design for up to 16 multi-input channels. Both systems feature math

utilities and channel comparison capabilities that enable the real-time display of virtual channels unavailable by direct measurement. They also provide FFT analysis for any or all channels.

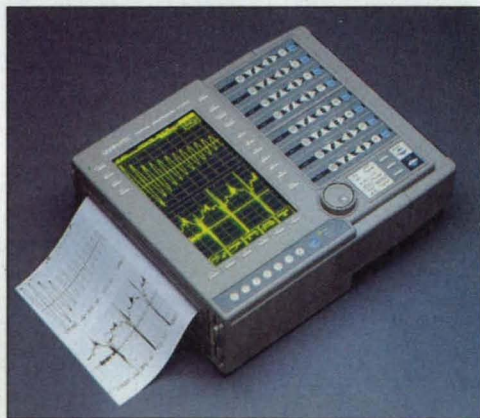
SMART triggering and TTL logic interfaces enhance diagnostics and control capabilities. And their Waveform Judgement Function

enables them to instantly identify out-of-tolerance conditions and make GO/NO GO decisions for alarms and controls.



Long a premier supplier of data recorders, Graphtec Corporation has taken the lead in making chart recorders perform like computers – by incorporating storage capacity, analytical capabilities, and real-time displays, while retaining the basic portability and ease-of-operation of traditional recorders.

The DMS1000 Data Management System streams data directly to internal storage media at rates that let it combine up to 40 channels of static and dynamic data. Its programmability provides sophisticated analyses of process, machine, or medical variables. And Boolean Search software enables users to create



Western Graphtec Inc.
11 Vanderbilt
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Fax: 714-855-0895
E-mail: inst_sales@graphtecusa
www.graphtecusa

Circle No. 832 On Fax Form



Krytox®

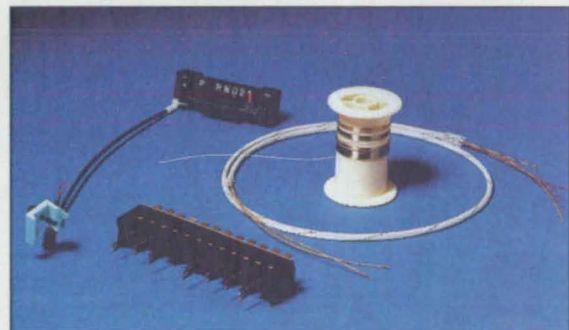
performance lubricants

DuPont Krytox® Performance Lubricants: Offering a Lifetime of Reliability

DuPont Krytox® performance lubricants have set the standard for cost-effective lifetime lubrication of bearings, gaskets, seals, and other small parts for more than 35

years. Krytox® keeps its lubrication characteristics for extended periods in temperatures ranging from -57 °C (-70 °F) to 343 °C (650 °F) – a range much broader than other synthetic lubricants. It also maintains good viscosity over a wide temperature range.

All Krytox® lubricants are nonflammable and nonreactive with virtually all chemicals. Because Krytox® provides extra protection against aggressive chemicals that degrade conventional lubricants, it



is useful in applications that cannot tolerate system shutdown or failures. Krytox® is also completely resistant to attack by gaseous and liquid oxygen.

Krytox® wets metallic surfaces easily due to its low surface tension. It also offers compatibility with all elastomeric materials and engineering plastics.

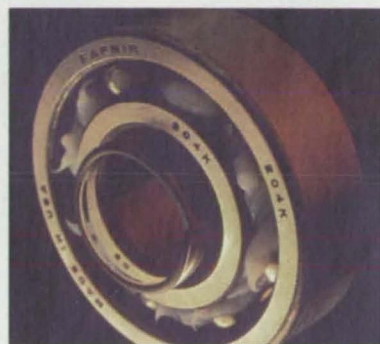
The History of Krytox®: From Space to Almost Every Place

In 1958, NASA approached DuPont scientists to create a high-temperature lubricant for the space program that was safe, long-lasting, nonflammable, and chemically inert...and the original Krytox® formulation was born.

In the early '80s, Krytox® found a large niche in the semiconductor industry as a lubricant for mechanical pumps used in the wafer manufacturing process. A general-purpose line of Krytox® high-performance lubricants soon followed, offering longer component life and reliability to the aerospace, automotive, appliance, chemical processing, corrugating, and many other industries.

Krytox® Oils and Greases: the Standard for Longer Life

Krytox® oils and greases feature a winning combination of properties that ensure effective performance in a wide range of high-tech and industrial applications.



Krytox® Dry Film: a Clean Solution for Moving Parts

DuPont Krytox® dry film can reduce the coefficient of friction in a wide range of applications to create nonstick surfaces and facilitate parts movement.

In the cable assemblage of a gear-shift indicator, Krytox® dry film provides moving plastic surfaces with lubrication and wear protection. For the internals of switches, a coating of Krytox® dry film permits easy movement without attracting dirt. In wire drawing, Krytox® dry film coats wire as it is pulled

through a die, reducing heat generated and increasing the speed of the pull. A coating of Krytox® dry film also provides wires with improved strippability and improved movement within wire jackets.

Krytox® dry film also produces a lower coefficient of friction in mold release applications, allowing rubber and plastic parts to eject faster and cleaner.

For more information, call the DuPont Krytox® hotline at 1-800-424-7502, or visit the Performance Lubricants web site at <http://www.lubricants.dupont.com>.



DuPont Specialty Chemicals
Chambers Works,
Tech Lab D+
Route 130, Canal St.
Deepwater, NJ 08023
Tel: 1-800-424-7502

Circle No. 838 On Fax Form



John B. Jones, Assistant VP, Inco, Ltd. & General Manager, ISPP

INCO SPP is the Special Nickel Products Business Unit operating within Inco Ltd., the world's leading nickel company. This has been an exciting year for Inco. The company has taken ownership of the high-grade Voisey's Bay mining deposit in Canada, described as the mineral find of the century. We have strong future plans to produce large volumes of metal at potentially the lowest-cost source of nickel in the world. This will help us continue the development and growth of the Special Nickel Products Business with our customers, as a fully integrated supplier.

At our refineries in North America and Europe, we continue to expand our range of nickel powders made with different morphologies and sizes, and all produced with ISO 9002 quality. This year, for example, has seen considerable growth and investment in our new micron-size filamentary nickel powders. We also are continuing to find ways in which to use the properties of the intermediate gases from our major nickel refineries to directly deposit pure nickel onto new products such as nickel-coated carbon fibers, nickel-coated graphite particles, battery-grade nickel foam, and net shape nickel parts.

We are concentrating our business objectives to provide full service to our customers in rechargeable batteries, advanced electronics, and automotive parts, and we constantly seek new applications where we can, together with our customers, develop effective use of the unique properties of our nickel products.

INCO Specialty Powder Products

**145 King Street West, Ste. 1500
Toronto, Ontario, Canada
M5H 4B7
Tel: 416-361-7859
Fax: 416-361-7659**



Products and Applications

Inco Special Products consists of a wide range of high-purity nickel powders from our North American and European refineries. The nickel all originates from Inco's own mines, giving us long-term, integrated supply relationships with our customers.

Inco's unique gas decomposition technology allows the powder shapes and sizes to be designed to individual customer applications. Fine powders of filamentary, equiaxial, spherical, and other shapes can be made. The latest addition has been an extra-fine micron-size nickel powder, Inco Type 210, now in growing use for conductivity additives, hard metal binders, and fast-sintering thin nickel layers or paints.



INCOFIBER Nickel-Coated Fibers

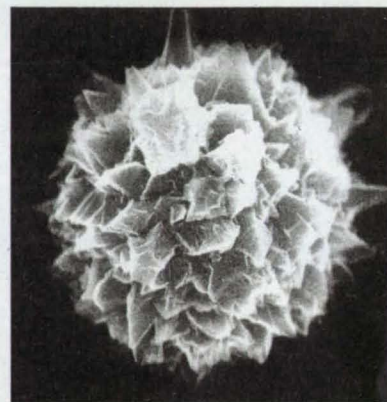
The Inco Type 123 equiaxed spiky powders have been further improved in quality to allow powder metallurgy sintered part producers to gain the benefits of the nickel addition to their low alloy steel compositions with very consistent results from part to part.

Inco's filamentary powders, from Type 255 to Type 287, find applications for sintered electrodes in rechargeable nickel batteries and fuel cells, and many diverse electronic and filter uses, which make use of their shapes, sinterability, and conductivity.

Inco produces high-purity black nickel oxides to electronic ferrite and catalyst specifications, and for new uses in lithium ion rechargeable batteries.

The Novamet Company in New Jersey is part of Inco's Special Product Business. It produces a range of quality metal flakes and conductive fillers, including nickel and stainless steel for the paint and coatings industries.

One of the latest additions to our product line has been a new range of nickel-coated carbon fiber products – INCOFIBER™ in the continuous and chopped fiber form, and INCOSHIELD™ in the nickel concentrate pellet form. The nickel coating is done at an Inco refinery by a unique chemical vapor deposition that deposits a high-purity nickel layer onto the carbon fiber in a very consistent manner.



Inco Nickel Powder Type 123

Typically, the INCOSHIELD™ nickel concentrate pellets are made to a fiber/resin ratio of 60/40 wt%, and a selection of polymers can be used; for example, polycarbonate or polyamides.

Applications for these new fibers and concentrates include EMI shielding in plastic injection molded parts for the consumer electronics and automotive industries, aerospace uses such as lightning and de-icing protection, and for sporting goods and conductivity additives in batteries.

Nickel-coated graphite particles are also available for use in conducting gaskets, again in consumer electronic parts. New applications are also being developed for metal matrix composites with aluminum alloys.

In addition to the described product range, INCO SPP is pleased to work cooperatively with customers to develop individual specifications and applications that meet their needs. INCO SPP is represented through sales offices with specialist sales personnel in the major geographic markets of the world. Research and development in support of the INCO SPP product range and of new products is done at the Inco Corporate Laboratory in Mississauga, Ontario, Canada.

Circle No. 839 On Fax Form



As a world leader in the manufacture and supply of advanced indium-based products, Arconium has established a well-deserved reputation for technical excellence through formidable research and development efforts. These endeavors have enabled the company to broaden an extensive product line that includes indium-based solders, salts, oxides, plating chemicals, fusible alloys, and sputtering targets. By pursuing the virtually unlimited applications this element holds, Arconium has been able to provide emerging technologies in many diverse industries with a single source for all their indium needs.

Contact Information:

Arconium, 50 Sims Avenue, Providence, RI 02909; Tel: 401-456-0800 or 800-343-0282; Fax: 401-421-2419; E-mail: arconium@emd.cookson.com; www.arconium.com

Circle No. 885 On Fax Form



Space-Age Coatings for Metal Parts Resist Abrasion & Corrosion

Magnaplate surface enhancements solve even the toughest metal wear and performance problems. These Magnaplate-applied coatings create a harder-than-steel, permanently dry-lubricated surface that resists abrasion, corrosion; also exhibits superior mold release. Can be controlled for electrical/thermal conductivity. Most meet FDA, USDA, and Agriculture Canada codes for food/drug applications. New eight-page Engineering Data Guide details hardness, friction, wear, temperature, thickness, and other properties, plus applications.

face that resists abrasion, corrosion; also exhibits superior mold release. Can be controlled for electrical/thermal conductivity. Most meet FDA, USDA, and Agriculture Canada codes for food/drug applications. New eight-page Engineering Data Guide details hardness, friction, wear, temperature, thickness, and other properties, plus applications.

Contact Information:

General Magnaplate, Linden, NJ 07036; Tel: 800-852-3301; Fax: 908-862-6110; E-mail: info@magnaplate.com; Web site: <http://www.magnaplate.com>

Circle No. 868 On Fax Form



We Focus on Materials ... So You Can Focus on Results

Since 1980, when we developed zinc infrared transmitting materials by the chemical vapor deposition method, Morton has remained at the forefront of this technology. No other company can match our experience, production capacity, technical expertise, and service. We do it so well because materials is all we do. Every resource is focused on producing the best quality CVD ZINC SELENIDE®, CVD ZINC SULFIDE®, and CLEARTRAN®. That's why you can count on our materials for results.

Contact Information:

Morton Advanced Materials, 185 New Boston St., Woburn, MA 01801; Tel: 617-933 9243 or 800-552-2283; Fax: 617-933-5142; Web site: <http://www.mortoncvd.com>

Circle No. 869 On Fax Form



Shape the Future With CVD SILICON CARBIDE®

Chemically vapor deposited beta CVD SILICON CARBIDE offers high-purity (99.9995%), superior chemical resistance, thermal conductivity ($>300 \text{ Wm}^{-1}\text{K}^{-1}$), stiffness and polishability ($< \text{\AA}$ RMS). More than a coating: CVD SILICON CARBIDE

fabricated parts are available up to 40" OD and 1" thick. In semiconductor processing, optics, wear components, and electronic packaging applications, CVD SILICON CARBIDE is shaping new ideas. Contact us today with your design requirements and together we can shape your future.

Contact Information:

Morton Advanced Materials, 185 New Boston St., Woburn, MA 01801; Tel: 617-933 9243 or 800-552-2283; Fax: 617-933-5142; Web site: <http://www.mortoncvd.com>

Circle No. 870 On Fax Form

Your Fabrication Source Papers • Films • Foils • Foams • Rubber • Adhesive Tapes

Precision Converting can help you solve your bonding, masking, friction control, and EMI/RFI shielding applications with close tolerance fabricated materials. Our capabilities include: laminating substrates to pressure sensitive adhesives (up to 52" wd). Diecutting using steel rule dies, rotary dies, and dedicated die sets. We also provide slitting, cut-off, and perforation services.

Contact Information:

Precision Converting, 1750 S. Los Feliz Dr., Ste. 112, Tempe, AZ 85281; Tel: 800-829-0844; Fax: 602-829-0189

Circle No. 867 On Fax Form



Reflective System Bonding Tape System

Trim-Lok, Inc., a leader in the plastic and rubber extrusion manufacturing field, is proud to introduce its "Reflective System" and "Bonding Tape System." Reflective System, available in a variety of trims, reflects night light up to 200% its normal bright-

ness, providing an alternative and affordable safety feature. Bonding Tape System offers a better way to attach rubber-extruded profiles, heat-fusing tape directly to the rubber, providing an air- and moisture-tight seal eliminating tape failures in applications.

Contact Information:

Trim-Lok, Inc., 6855 Hermosa Circle, Buena Park, CA 90622-6180; Tel: 714-562 0500

Circle No. 852 On Fax Form



Metal Belts That Drive Productivity

The Company

Belt Technologies, Inc. (BTI) is an ISO 9001 registered company that has been designing and manufacturing metal belts, drive tapes, and related pulleys for over 25 years. With our sister company, Belt Technologies Europe (BTE), we service engineers worldwide with state-of-the-art products that have stood the test of time in the most demanding and diverse applications imaginable.

World leaders in aerospace, telecommunications, electronics, imaging, packaging, and pharmaceuticals, as well as consumer products, rely on systems utilizing our products. BTI is noted for its rapid, accurate, and reliable manufacturing and attention to customer service.

Our organization is structured to provide design assistance, specialized components, and prototypes, in addition to high-volume production that may be part of long-term blanket contracts.

The engineering staff at BTI combines expertise in metallurgical, mechanical, and

Why Belt Technologies' Products are Better

Metal belts and drive tapes from BTI have several unique and important characteristics simply not found in other drive components including:

- They are essentially unstretchable
- They possess extremely high strength-to-weight ratios
- They are accurate and repeatable
- They require no lubrication
- They are clean
- They are thermally and electrically conductive
- They operate in hostile environments
- They are quiet and generate no cordal vibration

Typical dimensions range from 0.100" wide to 32.0" wide and from 0.002" thick to 0.030" thick. Lengths range from 9.0" to hundreds of feet. Remember, these are only typical dimensions.

Perforations and Coatings

Metal belts can be designed to incorporate a broad range of coatings, perforations, or attachments in countless combinations. A few applications for these belts include nested parts conveying, high-speed packaging, oriented component transfer, vacuum conveying, indexed assembly and inspection, and automated cleanroom transfer lines.

Drive Tapes

Frequently, BTI designs and fabricates metal strips with end attachments which we call "drive tapes." These drive tapes exhibit the same desirable characteristics as our metal belts, but are used in very different situations.

Specialized end attachments interface with customer-designed hardware, such as shafts or carriage assemblies, to transmit motion – typically reciprocating – in zero or near-zero backlash applications. Some of the more common installations of drive tapes can be found in high-resolution plotters or in imaging equipment of various designs.

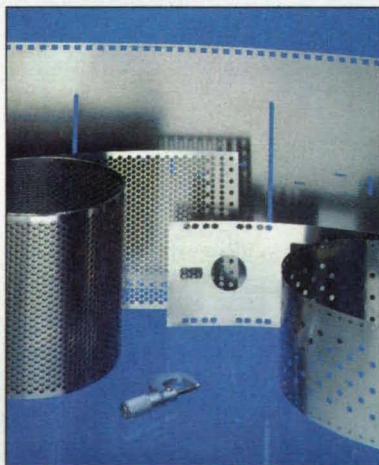
Like metal belts, drive tapes are designed and manufactured across a broad range of sizes utilizing many high-strength, high-quality alloys.

Precision Pulleys

A precision metal belt or drive tape cannot deliver the accuracy, repeatability, or longevity it is capable of providing if it is operating on substandard, inadequate pulleys. BTI manufactures pulleys to exacting standards in order to assure design objectives are achieved and system integrity is maintained.

Pulleys may be smooth-faced, to be used as idlers or as driving pulleys in friction drive applications, or they may incorporate timing teeth or pockets to be used in indexing or trimming applications. General designs and sizes are as varied as are our metal belts.

BTI currently has two pulley patents and two more are pending. One of the existing patents is applicable to our style that uses



industrial engineering with years of applications experience to help our customers achieve optimal performance from their metal belt or drive tape-based system. Detailed design engineering and drawing generation is usually completed by BTI or BTE at no charge to the customer.

Belt Technologies, Inc.
PO Box 468
Agawam, MA 01001
Tel: 413-786-9922
Fax: 413-789-2786

precision ball bearings as timing teeth. The other patent applies to our "Independently Steerable Pulley (ISP)." This ISP allows the user to make belt steering adjustments directly from the pulley without having to adjust the pulley shaft.

The ISP, for the first time, enables the engineer to mount several pulleys on a common shaft and steer all independently. The ISP also enables the engineer to design into the system real-time automatic belt tracking.

Company Commitment

Belt Technologies, Inc. has been committed to assisting our customers in improving their designs by employing metal belt technology for over two decades. Metal belts and drive tapes from BTI truly do drive improvements in productivity in a cost-effective, proven fashion. We encourage potential new users of this technology to contact us for more detailed information and design assistance.

Circle No. 840 On Fax Form

New Spring-Fast Cushion Grommets Protect Fiber Cables From Abrasion

New Spring-Fast® Cushion Grommets from Device Technologies, Inc. feature a soft polymer cushion to protect cables and wires from abrasion caused by rough edges in sheet metal and other materials.

Originally developed for sensitive fiber optic cable telecommunications applications, Spring-Fast Cushion Grommets are also ideal for applications such as airframe, medical, computer, and peripheral products.

UL94V-0 rated, Spring-Fast Cushion Grommets are made of nylon-coated stainless steel, with a soft (90 Shore A) polymer cushion to provide maximum protection for cables. Durable, strong, and flexible, Spring-Fast Cushion Grommets conform to any two-axis contour.

One-Step Installation

These new cushion grommets offer easy, one-step installation, as



the grommet edging snaps into place in seconds. Unique spring gripping fingers hold fast. Unlike other grommets, Spring-Fast Cushion Grommets require no adhesives, thereby saving time, labor, and adhesive costs, and ensuring a lower installed cost. In addition, eliminating adhesives and/or degreasing solvents addresses environmental concerns with toxins and/or VOCs.

A Variety of Sizes

New Spring-Fast Cushion Grommets are offered in several sizes for sheet thicknesses ranging from 0.025" (0.6 mm) to 0.250" (6.44 mm). The grommets are available in economical factory pre-cut lengths, in kits, and in 25-foot and 100-foot reels. Colors are available on special order.

Device Technologies, Inc. designs and manufactures a complete line of Spring-Fast® composite grommet edging. Call to request a free sample or for more information.

Device Technologies, Inc.
3 Brigham Street
Marlborough, MA 01752-3140
Tel: 800-669-9682 or
508-229-2000
Fax: 508-229-2622

Circle No. 887 On Fax Form

Our mission is to be the best supplier, worldwide, of the highest-quality fluid system components, readily available to industry and supported by service that is technically sound, customer-driven, and of the highest quality.

The proven designs of our products assure maximum reliability in process and production, instrumentation, new construction, research and development, hydraulics, and pneumatics. We manufacture our products from a broad range of metals and plastics. Such versatility permits them to be used in applications involving high or low pressures or vacuum, at high or low temperatures.

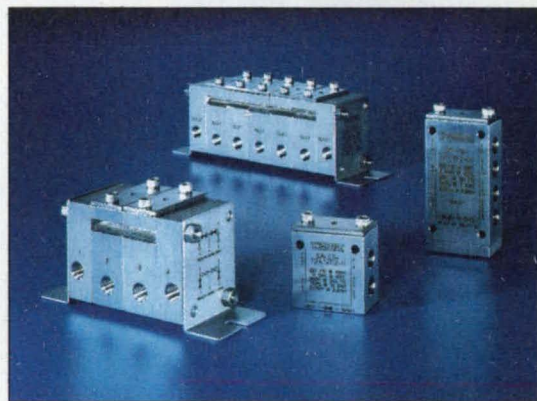
Availability, reliability, and versatility come with every product you buy from the Swagelok companies.



Unique Whitey Valves Improve Sampling Systems

The new T2 Series, a unique collection of pneumatically actuated valves for liquid or gas sampling systems, is now available from Whitey Co., one of the Swagelok companies. A variety of configurations is available to meet diverse sampling needs for on-line process analyzers.

There are five basic groups within the T2 Series designed to address different customer needs: sample stream select network valves, process gas chromatograph network valves, continuous emissions monitoring system valves, shut-off valves, and three-way valves. Variations within the basic groups are available to meet even more specific application needs.



Each member of the T2 Series contains elements that improve existing sample system design, performance, and reliability. The valves are compact to reduce housing and enclosure costs. They feature low or no dead volumes, which permits quick and economical purging. Built-in pneumatic actuators reduce sample system costs, while the variety of available end connections provides system versatility.

The valves feature live-loaded seals and a leak detection port to detect or capture fugitive emissions. These features also work in combination to prevent the actuation media from mixing with the system media.

Standard 316 stainless steel wetted components provide superior corrosion resistance to most system fluids. An all-stainless-steel actuator and valve assembly maintains system

integrity. The valves withstand temperatures ranging from 0°F to 300°F (-15°C to 150°C) and pressures up to 300 psig (21 bar).

Fittings Make Global Connections

Swagelok® Tube Fittings make it easy to join metric tubing to fractional tubing or pipe. The wide range of available configurations offers solutions to most connection problems and avoids expensive remachining or backwelding.

Swagelok tube fittings connect:

- metric tubing to fractional tubing
 - metric tubing to fractional pipe
 - metric and fractional tubing to ISO/BSP parallel or tapered pipe ports
 - metric tubing to NPT pipe ports
 - metric tubing to fractional pipe weld ports
- Configurations include male connectors, bulkhead male connectors, male 90° elbows, positionable male 90° elbows, male branch tees, female run tees, female connectors, unions, male pipe weld connectors, reducers, and male and female tube adapters.

Materials are 316 stainless steel, carbon steel, brass, and special alloys. Sizes are 1/16" to 2" and 2 mm to 38 mm. Applications include fluid power,



instrumentation, process, lubrication, sampling, air, steam, and water systems. Swagelok tube fittings are available worldwide from local stocks.

The Swagelok Companies
Solon, OH 44139

Circle No. 841 On Fax Form

BERG

W. M. BERG, INC.
PRECISION MECHANICAL COMPONENTS

W.M. Berg, Inc., manufacturers of precision mechanical components, is known worldwide for quality, reliability, and service. Our non-metric catalog contains more than 60,000 standard line items and our metric catalog more than 30,000 items including gears, chain and belt drives, gear assemblies, linear components, couplings and clutches, bearings, fasteners, shafts, and shaft hardware. Our experienced engineering staff is trained to work directly with designers and engineers in the design, development, and fabrication of custom parts.

Contact Information:

W.M. Berg, Inc.; Tel: 800-232-BERG; Fax: 800-455-BERG

Circle No. 853 On Fax Form



Better, Smaller, CSF Harmonic Drive Gearing

HD Systems uses their patented "S" tooth to produce a harmonic drive gear that is nearly 50% smaller, yet provides

twice the torque capacity, life, and torsional stiffness when compared to conventional harmonic drive gears. The CSF Series accomplishes this while maintaining zero backlash. A complete range of sizes and ratios are available with continuous torque ratings ranging from 6 to 2618 ft-lbs.

Contact Information:

HD Systems; Tel: 800-231-HDSI; Fax: 516-231-6803.

Circle No. 884 On Fax Form



Series 1 and 2 Teflon Solenoid Valves

General Valve's Teflon® solenoid valves feature low internal volumes, fast response times, and high cycle life. General Valve

stands apart from the competition with coils rated for continuous duty, 100% testing, and bodies made from virgin compression molded PTFE. Valves are available in a variety of orifice sizes, voltages, and port connections.

Contact Information:

Parker Hannifin Corp., General Valve Division, 19 Gloria Lane, PO Box 1333, Fairfield, NJ 07007; Tel: 800-GVC-VALV (800-482-8258); Fax: 800-GVC-1FAX (800-482-1329); E-mail: gvc@genvalve.com

Circle No. 871 On Fax Form



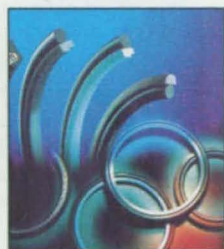
Continuous Hinges

Application and selection criteria for continuous hinges of virtually any type are defined in a 16-page catalog. It includes an instructive section on hinge terminology, data on secondary and finishing options, dimensional drawings, specs and tolerances, standard sizes with metric conversions, and estimated shipping weights. The hinges are available in almost any length, width, and finish.

Contact Information:

Stocker Hinge, Box 149, Brookfield, IL 60513; Tel: 800-631-2600 or 708-485-3400; Fax: 708-485-0058; Web site: <http://www.stocker.com>

Circle No. 872 On Fax Form



Aerospace Sealing Systems

For more than 40 years, Busak+Shamban sealing systems have been the leading choice for high performance, quality, and cost-effectiveness. Actively involved in commercial and defense applications since the

beginning of the aerospace industry, our seals can be found on most aircraft hydraulic systems, including flight control and utility actuators, accumulators, braking systems, and landing gear. With technical support all over the world, we can provide you with a total solution, consistent with all international accreditation and certification standards.

Contact Information:

Busak+Shamban Seals Division; Tel: 800-767-3257

Circle No. 874 On Fax Form

Electroid Company

Ever since its founding in 1949, Electroid Company has specialized in electromagnetic devices for rotary motion control, including clutches, brakes, clutch/brake modules, permanent magnet devices, magnetic particle devices, power supplies, and tension control components. We are recognized by the most demanding industrial, commercial, and military/aerospace specifiers as being dedicated to excellence in both product and service. Custom design is Electroid's specialty. We conform to MIL specs, including MIL-Q-9858 and MIL-I-45208 and supply superior motion control products based on innovative engineering, well-tuned manufacturing, and uncompromising quality control.

Contact Information:

Electroid Co., Div. Of Valcor Engineering, 45 Fadem Rd., Springfield, NJ 07081; Tel: 201-467-8100; Fax: 201-467-5656

Circle No. 873 On Fax Form

Custom Servo Motors Inc. Provides High-Performance Motion Control Solutions

The performance of machinery and equipment is defined by the power of the motor driving the equipment. And today, OEMs are demanding higher and higher performance when designing equipment. High-performance motors can be evaluated by three key requirements: torque to volume, torque to inertia, and torque per dollar.

Custom Servo Motors Inc., New Ulm, MN, a subsidiary of MTS Systems Corporation, provides OEMs with MaxPlus™ Series servo motors that feature more torque to volume, more torque to inertia, and more torque per dollar than competitive servo motors available in today's market. Using Delco Remy's Magnequench® MQ3 magnet material enables Custom Servo Motors' MaxPlus family servo motors to generate more torque in less space. As proof, Custom Servo Motors' 2-inch servo motor provides 10 in.-lbs. of continuous torque with 4 lbs. of mass. Its 12-inch servo motors, the largest size it offers, provide up to 3,600 in.-lbs. of continuous torque with 590 lbs. of mass.

The MaxPlus 2-inch servo motor goes from a full stop to 3,000 rpm and back down to a full stop in 12.5 milliseconds, demonstrating more torque to inertia than competitive servo motors. The exclusive design of the entire servo motor line provides machinery OEMs with more torque per dollar that they spend.

Patented Multiple Wound Servo Motor Package

The patented MaxPlus spindle motor package delivers high torque at low speeds without the cost and bulk normally associated with conventional motors and gear boxes. It also

operates equally smoothly at high speeds without generating excessive heat. The new servo design uses three motor windings: a Y-shaped series configuration, a Y-shaped parallel configuration, and a "Delta configuration." By employing multiple windings to create an "electronic transmission," the new motor operates at a constant horsepower regardless of speed. With this patented design, the motor can achieve torque rating of 250, 550, and 1000 in.-lbs. when operating off any single winding.

MaxPlus Amplifiers

In addition to offering OEMs powerful servo motors, Custom Servo Motors Inc. provides a full line of matching amplifiers designed to be used interchangeably with all its motors. With this unique capability, customers get a truly optimized package to meet their demanding and specialized needs.

A new line of high-performance configurable amplifiers, the MaxPlus multiaxis drive offers machining OEMs efficient X-Y-Z axis control. The modular drive features a common power supply, reducing AC wiring to a single connection. Unlike most drives of this type, heat sinks or fans are not required to produce desired performance and brush or brushless tacs yield low speed smoothness. And the modular architecture gives Custom Servo Motors Inc. the ability to quickly adapt the product to meet special OEM needs. By separating the front-end functions from the fixed power stages, the engineering staff can easily customize the product to maximize the performance of the particular machine.

High-Performance Motion Controllers

The MotionPlus™ Series of motion controllers provides the OEM with a full range of motion control solutions including state-of-the-art motion control solutions for increasing productivity and production flexibility. An assortment of standalone controllers is available to meet a variety of capabilities, including cyclical functions such as rotary



knife, index, and flying shear cycles. Digital controllers are available with one to 28 axes of control, depending on an application's sophistication.

For applications where motion requirements are simple and space is limited, Custom Servo Motors offers its MaxPlus Digital Signal Processor, a DC servo amplifier with a built-in, DSP-based, one- or two-axis controller. It is a fast, compact, and economical digital controller that is built into the servo amplifier and is capable of running either as a host-based system or as a standalone unit.

Both the MotionPlus digital controllers and MaxPlus Digital Signal Processor are designed for panel mounting on new, as well as retrofit, machinery.

Custom Servo Motors' turnkey solutions combine its powerful servo motors with a full line of amplifiers and motion controllers to provide the speed to increase productivity and the flexibility to implement fast product changeovers.

In addition to its standard products, Custom Servo Motors specializes in providing its customers with unique, specialized products in short turnaround times. The company's experienced application engineers design servo systems to meet specific customer performance, size, and durability requirements.

MaxPlus™ is a trademark of Custom Servo Motors Inc. MotionPlus™ is a trademark of Custom Servo Motors Inc. Magnequench® is a registered trademark of Delco Remy.

Circle No. 842 On Fax Form

Custom Servo Motors Inc.
A Subsidiary of MTS
Systems Corporation
2121 Bridge Street
New Ulm, MN 56073
Tel: 507-354-1616 or
1-800-967-1785
Fax: 507-354-1611

Litton

Poly-Scientific

Truly Innovative Rotary Motion and Control Capabilities From Litton

Litton Poly-Scientific designs and manufactures slip rings, Clifton Precision® motors, resolvers, and higher order assemblies, which can include drive and control electronics. Our extensive in-house engineering expertise allows us to design and produce "one-of-a-kind" custom products as well as volume-driven, extremely cost-sensitive standard products.

New Line of Brushless DC Motors from Litton

Our new BN23 brushless motor is designed for applications where low noise and long life are prime considerations, such as medical equipment, data storage equipment, and robotics. But applications for the BN23 are endless – material handling, pumps, blowers, textile and packaging equipment, and many more. Particularly well-suited to large-volume OEM requirements, the BN23 is also available in small quantities.

Call us with your motor design requirements (envelope size, torque, speed, and operating voltage usually suffice) and we can provide a computer model of your motor,



Features:

- 2.25" diameter
- Lengths from 1.3" to 2.8"
- Continuous torques from 7.5 to 56 oz-in
- Speeds up to 20,000 rpm
- Standard options include gearheads, resolvers, encoders, and electronic drivers
- Available soon in 34 and 42 sizes

The Clifton Precision® line of motors includes light-duty brush, brushless, cube, and torque models.

- Continuous 360° rotation of power or data signals
- Maintenance-free (no lubrication required)
- Rugged, high-impact thermoplastic shaft, frame, standard bearing, and cover
- Optional steel bearings and splash seals are available on special order

- Speeds up to 250 rpm continuous
- Collar mounting is standard with flange mount optional
- **One-week delivery**

Consider for: machining centers, rotary index tables, heavy equipment turrets or cable reels, test equipment, packaging machines, palletizing machines, robotics, process equipment, and rotary sensors.

Commercial Brushless Resolvers

Litton's brushless resolvers provide low friction levels and eliminate sparking and arcing. Their rugged design delivers reliable performance in the toughest, vibration-prone industrial and instrument environments.

Features:

- Sizes 11, 15, 21, 22, up to size 42
- Single speed and multispeed
- Different speeds, accuracies, and frequency ranges available

Consider for: brushless DC servo commutation, position, and velocity feedback; robotics and factory automation; machine tools; medical instrumentation; and packaging equipment, among others.

When it has to turn, turn to Litton.



optimized to match your application – usually in one or two working days. We can fax the model to you or download to your computer. This free service speeds prototyping and slashes manufacturing cycle times.

Commercial Slip Ring Line Keeps Growing

Slip rings provide unrestrained, continuous rotation while transmitting power and/or data from a stationary to a rotating structure in any electro-mechanical system. Slip rings are often an excellent solution to a tricky design problem. Litton's growing line of commercial slip rings now includes separates, high-speed, miniature, and 3/8" through-bore models. The capsule described below is one of our most popular, and available for quick delivery.

Slip Ring Capsule With Through-Bore AC4598/AC4831

The 1-1/2" unobstructed bore through the center allows for routing space for hydraulics, pneumatics, or for a concentric shaft mount.

Features:

- 1-1/2" through-bore
- 6, 12, 18, or 24 two-amp/210 VDC circuits
- 5A and 10A circuit models



Litton Poly-Scientific
1213 North Main Street
Blacksburg, VA 24060-3100
Tel: 800-336-2112 or
540-953-4751
Fax: 540-953-1841
E-mail: msg@litton-ps.com
www.litton-ps.com

Circle No. 843 On Fax Form

NESLAB: A Global Leader

NESLAB Instruments has been serving the temperature control industry for more than 30 years. NESLAB owns the 16-acre site in New Hampshire in which it operates. The facility is comprised of 180,000 square feet. NESLAB offers itself as a fully integrated manufacturer operating sheet metal, painting, and assembly departments in order to meet the flexibility required of small batch runs, short lead times, and substantial single custom designs.

NESLAB's end users are extremely varied by discipline and application, and operate in a large number of niche markets. However, as an overview, NESLAB's business is related to high-tech instrumentation, including lasers, medical equipment, and research apparatus.



NESLAB is the leader in its markets from a technology and installed base standpoint. In addition, NESLAB is the only truly global supplier of constant-temperature equipment capable of supporting its customers throughout the world.

NESLAB Instruments, Inc.
P.O. Box 1178
Portsmouth, NH 03802-1178
Tel: 800-4NESLAB or 800-258-0830
Fax: 603-436-8411
E-mail:
NESLAB@lifesciences.com
www.neslabinc.com.

The Constant Temperature Solution

NESLAB has solved thousands of cooling and temperature control problems with our wide range of recirculating chillers and refrigerated circulators. Years of successful relationships with our end users and OEM customers have made us a first choice among manufacturers using temperature control in conjunction with their processes. We supply cooling equipment to more than 70 major manufacturers of lasers for the analytical, medical, and industrial markets.

NESLAB also designs and manufactures high-quality recirculating chillers for cooling optics, photonics, and imaging equipment. NESLAB's staff of design and applications engineers can work closely with customers to design and manufacture equipment that will suit their needs.

Innovative Recirculating Chillers

The HX series of Recirculating Chillers feature our innovative hinged design, which allows easy access to internal components, including reservoir fill cover. Industrial-grade

pumps provide flows of up to 60 psi. NESLAB Recirculating Chillers are designed with oversized hermetically sealed refrigeration compressors for steady cooling and trouble-free, 24-hour-a-day operation. These chillers provide heat load removal up to 75 kilowatts spanning temperature ranges from +5°C to +35°C. Each cooling system can be ordered with temperature control options, pump options, and an extensive list of customizing options.



Circle No. 800 On Fax Form



Nazir Mulji, President

When we created Xantrex over a decade ago, we knew we had the people and the skills to compete with the best. Our goal was to be an industry leader. Today, we are in the forefront internationally. The reasons are: our innovative design, our policy of working closely with customers, prompt delivery of all products, and very competitive pricing. We guarantee satisfaction, from your first phone call, on through to after-purchase support. Ask anyone who has dealt with us.

We have developed several product series ranging from 60W to 2800W. We also custom-design solutions for specific applications. So what you require might not be shown or described, but it may be only a phone call away.

Xantrex

Products and Applications

Xantrex is a world-class designer and manufacturer of programmable DC power supplies for North America and international markets. Our products range from 60W to 2800W with voltage range from 0-600V and current range from 0-350A. All of our supplies are available with optional internal interfaces – IEEE-488 and RS232 – and are backed by a five-year warranty.

Our newest product is the XFR series, which is available in 1.2kW and 2.8kW power levels. The modular design of the supply is based on a common main board that is the same across two power levels and all voltage ranges. Small cards plug into the main board to tailor each unit's operating characteristics. What this means for you is faster delivery times and high performance at a lower cost.

The XFR Series caters to the application needs of electroplating, process control, magnet control, computer-controlled component burn-in, and other high-powered requirements.

Important characteristics of the XFR Series are:

- soft start operation limiting in-rush current on power-up
- lower losses in power and higher efficiency
- quiet operation
- multiple fans to maintain cooling and speed-controlled for long life
- analog programming as a standard feature

- multiple-level shut-down for safe operation

Our key strengths as a power supply manufacturer are our ability to quickly modify standard products to meet a variety of different requirements, and our fast delivery time.

Company History

Xantrex was founded in 1983 with the acquisition of the power supply division of Anatek Electronics. The Xantrex founders took the finest aspects of that company and combined them with unique business and engineering concepts.

From designing and building standard



XFR 40-30

product, the business expanded to include customized solutions for clients at home and abroad. By dominating the Canadian market and simultaneously branching out to the U.S., European, and Asian markets, Xantrex has grown from 40 employees in 1994 to over 100 in 1996. Year after year, Xantrex has built up a solid global reputation through strategic marketing and other key relationships. Our targeted success in the research and development market has allowed us to out-perform competitors by introducing the right products at the right time. And we're expanding our line of products all the time.



Xantrex main office in Burnaby, BC, Canada

Xantrex
3873 Airport Way
Bellingham, WA 98227-9754
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800-667-8422
Fax: 360-671-3095
E-mail: xantrex@xantrex.com
www.xantrex.com

Circle No. 825 On Fax Form



New Thermoelectric Products for Electro-Optic Cooling

Melcor, the world's leading manufacturer of thermoelectric cooling products, introduces the OptoTEC™ series of thermoelectric products and services. OptoTEC is designed specifically for electro-optic applications such as cooling and stabilizing of laser diodes, IR detectors, and CCDs. The line consists of single and multi-stage standard modules along with high-temperature (to +200°C), telecom grade and custom packaging, assembly options, and an all-new high-performance material.

Contact Information:

Melcor, 1040 Spruce St., Trenton, NJ 08648; Tel: 609-393-4178; Fax: 609-393-9461

Circle No. 860 On Fax Form



Welker Bearing Company, Troy, MI, has been a manufacturer of bronze and lubrication-free bearings for over 70 years. Welker has expanded its product line to include maintenance-free linear slides and cylinder driven shot pin assemblies. Welker recently has introduced a patented compact pneumatic lifter that is maintenance-free and symmetrically reversible. The new lifter is extremely rigid in the extended position with high repeatability. Lifter available with redundant brake.

Contact Information:

Welker Bearing Co.; Tel: 800-229-0890

Circle No. 861 On Fax Form



ZERO Enclosures: The Complete Source

Cases, containers, enclosures, covers, and housings – whether you need a round, square, or rectangular enclosure or a case to carry or ship your sensitive equipment, know that ZERO Enclosures is the best source in the industry to meet your needs. Our products range from highly specialized, engineered cases to over 100,000 pre-tooled sizes of deep drawn enclosures.

Contact Information:

ZERO Enclosures; Tel: 800-545-1034 for a complete catalog

Circle No. 862 On Fax Form



Testing Equipment

ATS manufactures a wide variety of testing equipment for your testing needs. Our standard ovens and furnaces can be custom-made for special testing, laboratory, and industrial processes. Oven temperatures reach 800°F (425°C), and furnace temperatures reach 3100°F (1700°C). Cooling accessories, temperature controllers, retorts, mounting brackets, and other accessory items also are available. Nondestructive testing equipment (ultrasonic reference blocks and EDM notches) are made according to specifications. Creep testing systems, universal testing machines, and accessories also are available.

Contact Information:

Applied Test Systems, 348 New Castle Rd., Butler, PA 16001; Tel: 412-283-1212; Fax: 412-283-6570

Circle No. 878 On Fax Form



Pocket-size Non-Contact Pyrometer with Laser Sighting is ideal for applications such as refrigeration, transportation, storage, electronics, and power facilities. Measurement range of -20 to 300°C or equal in Fahrenheit, laser sighting for measuring spot, automatic backlit LCD and automatic power-off, minimum or maximum temperature display and emissivity adjustable.

Contact Information:

CHINO Works America, Victoria Business Park, 18005 South Savarona Way, Carson, CA 90746; Tel: 213-321-3943 or 888-321-9118; Fax: 310-532-7195; E-mail: 2037900@MCIMAIL.COM

Circle No. 855 On Fax Form



Located in Grove City, PA, SATEC Systems designs, manufactures, and delivers high-quality materials-testing hardware and software equipment, service, and training to industrial, commercial, and institutional customers around the world. Tracing its roots to the legendary Baldwin universal testers, SATEC focuses on responding to its customers through its international force of highly trained sales, service, and technical personnel.

Contact Information:

Chris Schmitt, Director of Mktg., SATEC Materials Testing Equipment, 900 Liberty St., Grove City, PA 16127-9005; Tel: 800-373-4877; E-mail: satec@nauticom.net; Web site: <http://www.satec.com/www/satec>

Circle No. 879 On Fax Form

Products and Applications

For more than 30 years, Nicolet has specialized in high-precision measurements for the physical, mechanical, and electrical marketplaces. Our broad range of high-quality equipment and software is supported by many years of application experience in all these sectors. The following is an overview of our current products. For more information, please request a product brochure or visit our World Wide Web site at www.test.nicolet.com.

Transient Recorders

Nicolet is the world leader in transient recorders, offering a full line of card modular solutions.

- The **MultiPro**, a flexible, multi-channel solution featuring DSO-on-a-card performance
- The **2580P**, which combines up to 24 channels of transient acquisition in a single portable package
- The **BE256**, offering unparalleled filtering and channel memory capability

Continuous Recording Products

For monitoring and recording complex events over long time periods, Nicolet features two highly configurable product lines.

- For remote applications and data logging, the compact, rugged **MicroPro** offers unmatched channel density
- The new Nicolet **Odyssey** offers the first true replacement for traditional chart and tape recorders with real-time scrolling display and a full range of signal conditioning

Power and Isolation Products

Our specialty products for electrical labs include:

- A full range of high-voltage isolation devices
- The **PowerPro** Oscilloscope, the world's first high-precision oscilloscope designed for high-voltage applications
- A variety of specialized products for control and analysis of high-voltage and high-power test applications

High-Accuracy Oscilloscopes

The Nicolet **Pro Series** of oscilloscopes offers world class accuracy in two- and four-channel configurations including the Pro 90 and 92, the world's only oscilloscopes offering two independent sample rates for mixed speed acquisition. Other models include:

- 12-bit models from 1 MS/s to 20 MS/s
- 14-bit, 5 MS/s oscilloscopes
- 8-bit, 200 MS/s oscilloscopes

Software

Software functionality is quickly becoming the critical path to improved productivity. Nicolet specializes in control and analysis software to take you from sensor to report.

- **ProView** software puts unparalleled control, analysis, and custom report generation in a simple integrated package
- **TeamPro** software enables test automation for repetitive or production test applications. In addition, a wide variety of third party software packages are supported.

Company History

Nicolet has been a technology leader for more than 30 years. A few highlights of our early history include:

- 1965 - Fabri-Tek Instruments is formed in Madison, WI, its first product a digital signal averager.
- 1971 - The company goes public as Nicolet Instrument Corporation, named after French explorer Jean Nicolet, who first explored Wisconsin in 1634.
- 1972 - Nicolet introduces the world's first digital oscilloscope. Its original core memory soon gives way to 256-bit semiconductor memory.
- 1975 - First floppy disk drive and GPIB interface in an oscilloscope.
- 1983 - First portable digital scope.
- 1988 - First Microsoft® Windows®-based transient recorder.
- 1989 - Digital scopes become increasingly sophisticated: memory expands to 256K per channel, with removable hard disk and resident BASIC language.
- 1994 - The test and measurement group of Nicolet, renamed Nicolet Technologies, becomes a part of Thermo-Spectra Corporation, a subsidiary of Thermo Instrument Systems.
- 1995 - The innovative new MicroPro offers transient recorder performance in a data logger size.
- 1996 - New Odyssey data acquisition system is introduced with memory up to 200MW per channel and a DSP per channel.

Nicolet Technologies
5225-4 Verona Rd.
Madison, WI 53711
Tel: 608-276-5600

Circle No. 810 On Fax Form

About the Company

Since 1990, Spatial Positioning Systems, Inc. has been developing and manufacturing position measurement systems and applications software to service a wide range of industries. Through its patented and revolutionary laser-based technology, which instantly determines the 3D position of a desired point, increased productivity, high quality, and improved safety are achieved for numerous measurement applications.

Validated and tested with several years' support from a consortium whose members included Bechtel, Amoco, DuPont, Motorola, Army Corps of Engineers, Virginia Tech, and the Civil Engineering Research Foundation, the technology is ready to meet demanding applications.

Applications of Spatial Positioning's technology include surveying, site positioning and layout, equipment control, robotics, factory automation, large-scale assembly, digital modeling, alignment, inspection, surgery, hazardous waste mapping, space docking, instant CAD modeling, and virtual reality. These applications cover a broad range of industries, including construction, automotive manufacturing, shipbuilding, aerospace, movie production, medical equipment, and defense.

In addition to its off-the-shelf products, the company will also provide unique systems designed for special requirements, OEM systems for corporate added-value development, technology licensing for specialty markets, and specialized R&D under contract. Spatial Positioning welcomes organizations interested in discussing strategic ventures, software development, international marketing, and licensing opportunities.

Spatial Positioning Systems, Inc.
12007 Sunrise Valley Dr., # 200
Reston, VA 20191-3406
Tel: 703-648-9400 or
800-340-6388
Fax: 703-648-9422
E-mail: spsi1@aol.com
<http://members.aol.com/spsi1>



The Only Way to Measure in 3D: Odyssey™

From the builders of the Great Pyramids to the constructors of modern power plants, civilizations have long needed to locate and measure precise points within a frame of reference. From ancient string measures to modern optical instruments, no tool has been able to provide a highly accurate and instantaneous three-dimensional position at the point being measured. With such a tool, worldwide industries would become more efficient and productive. Today, this tool exists.

Odyssey... A Breakthrough in 3D Position Measurement

Odyssey is the world's first position measurement system that provides instantaneous, three-dimensional position information at the point being measured with millimeter-level accuracy. Our patented system of stationary laser transmitters and mobile optical receivers provides bottom-line cost savings both indoors and out. One or many simultaneous users, each with a mobile receiver, can move freely and quickly about the site gathering data: no pointing and



A portable receiver package consists of a belt pack and either an outdoor pole or indoor wand.

shooting of instruments, no instrument leveling, no waiting for signal acquisition, and no physical tether to a fixed location.

In recent tests on an evaluation site certified by the National Institute of Standards and Technology, Odyssey achieved three-dimensional accuracy of 1:15,000 (e.g., 0.67 mm at 10-m range) and precision (repeatability) of 1:75,000 throughout a 150-m range envelope.

This high degree of accuracy and precision makes Odyssey ideally suited for a wide range of industrial applications, including inspection, quality control, digital modeling, rapid prototyping, tracking, and workspace layout.

For example, Odyssey is being used today for activities such as test aircraft measurement, movie visual effects, construction-site surveying and layout, facility retrofit, environmental monitoring on hazardous sites, and crime-scene reconstruction.



Laser transmitters work both indoors and out, and operate in difficult environments such as fog, rain, dust, or darkness.

Odyssey...

- Higher Productivity
- Better Quality
- Less Rework
- Improved Safety

Circle No. 846 On Fax Form



Aromat

A Subsidiary of Matsushita

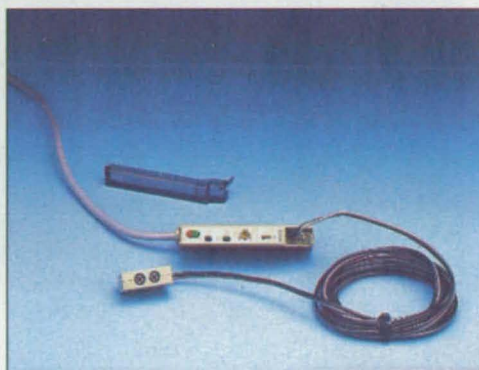
Aromat Is...Your Automation Controls Partner for the 21st Century

Aromat Corporation is an American company founded in 1974 to serve the North and South American markets. It is a wholly-owned subsidiary of Matsushita Electric Works, Ltd. (MEW), a \$10 billion company known throughout the world for the quality and innovation of its products.

Headquartered in Osaka, Japan, MEW is a major developer, manufacturer, and marketer of electrical construction materials, home appliances, residential building materials, automation control products, wiring devices, and electronic materials and components. MEW is a sister company of Matsushita Electric Industrial Co., Ltd., also of Osaka, Japan, the force behind such world-famous brands as Panasonic, Technics, and Quasar.



Drawing upon the tremendous resources of MEW, Aromat has grown into a \$200 million company with more than 500 employees located in two modern manufacturing facilities, three fully stocked distribution centers, nine sales and service offices, and corporate headquarters in New Providence, NJ. Aromat has become a recognized industry leader in creating advanced-technology products. Throughout its growth, it has remained dedicated to long-term performance through quality, value, and technology.



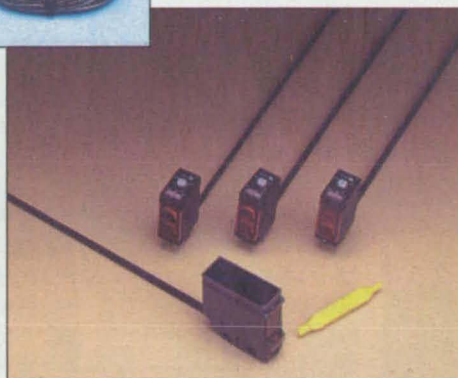
Photoelectric & Laser Sensors

Aromat offers a broad line of On/Off and Analog output photoelectric and laser sensors for detection and measurement of small to large targets on product assembly lines, automated warehouses, and on automated machining centers. They are used in a variety of manufacturing environments and applications.

These sensors utilize several different detection methods including area reflective (triple-beam technology), diffuse reflective, retroreflective, and thru-beam technologies. Model configurations are available to accurately detect objects regardless of color, material, or shape; and are unaffected by background objects outside the set range. Subminiature and fiber optic sensors also are available for applications where space is limited and speed needs to be optimized.

Compact, Self-Contained, Photoelectric Sensor Sees Difficult Targets

- Optical triangulation design provides reliable operation in clean or dusty environments
- Meets IP67 waterproof standard
- Not affected by target color, background, or changes in either



- Various sensing ranges from 20 to 200 mm
- Fast 1.0 millisecond response time

Sensor Setup As Simple As Pushing A Button

- Simple push-button setup
- Quick wire connection with one push of a lever
- Ultra-thin amplifier (10 mm)
- Nine different functions for advanced sensing techniques
- Fast response time of 0.6 milliseconds
- Infrared, visible red, and green transmission LEDs cover a wide variety of applications

Sensors

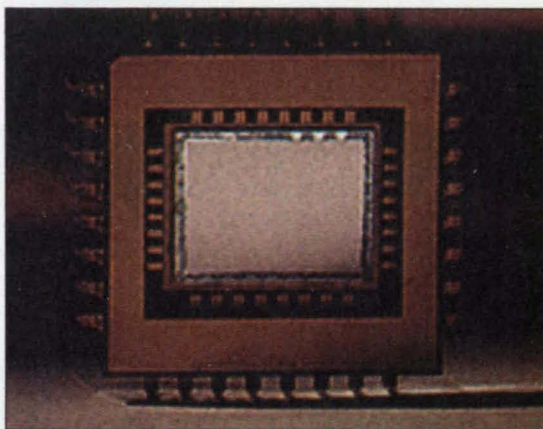
Aromat Corporation
629 Central Avenue
New Providence, NJ 07974
Tel: 908-464-3550
Fax: 908-771-5658
www.aromat.com

Circle No. 808 On Fax Form

Sarnoff

The David Sarnoff Research Center is a leader in developing sensing technologies for a wide range of applications, including measurement, identification, data collection, and communications. We have made major advances in imaging, communications, RF identification, optical detection, and short-range data transfer.

In microwave sensors, Sarnoff applies its long experience to such things as true-ground-speed sensors for locomotives, which increase load-pulling ability while saving fuel. Optical sources under



320 X 244 PtSi IRCCD

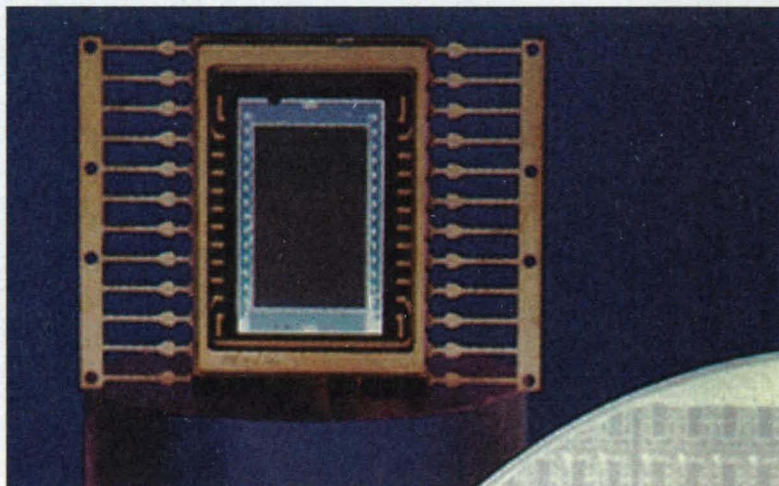
has applied CCD technology to everything from security systems to high-speed (1,000 frames/second) missile-tracking systems and a variety of visible and infrared cameras.

In IR and visible imaging systems, Sarnoff's expertise includes thinned-back, illuminated CCDs in a variety of output amplifier designs, vacuum-UV imagers, a monolithic platinum/silicon process, and a CMOS cryogenic multiplexer process. Sarnoff also manufactures its own high-frame-rate visible and IR CCD camera systems.

Sarnoff has two decades of experience in advanced silicon imager design, process technology development, imager design optimization, and product fabrication. We offer an extraordinary combination of foundry service flexibility and technology performance that includes full-service design and fabrication of final products.

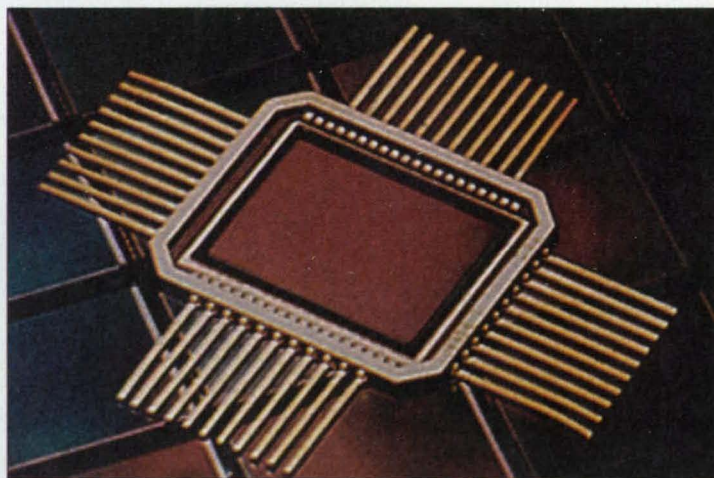
History

Established in 1942 as the RCA Laboratories and a wholly-owned subsidiary of SRI International since 1987, Sarnoff is one of the world's leading research and development organizations in solid-state electronics. President and CEO James E. Carnes heads a growing staff of 780.



Visible Back-Illuminated CCD

development include ones with the ability to detect gas levels in the parts-per-billion range without interference. With more than 15 years of experience in RF identification and data-transfer systems, Sarnoff has developed products ranging from simple, inexpensive passive identifiers to sophisticated active remote transponders. An example is a credit-card-sized tag with more than 56 billion reprogrammable codes that can be remotely read or written to at ranges up to six meters. With three decades of experience in focal-plane-array development, Sarnoff



640 X 480 IR Multiplexer

David Sarnoff Research
Center
Business Development
CN 5300
Princeton, NJ 08543
Tel: 609-734-2553
Fax: 609-734-2443

Circle No. 844 On Fax Form

Tiny Tower for Power

Towering 20mm above your board and chewing up 225mm² (15mm x 15mm base) of real estate, it is hard to believe why anyone would want to use a power supply current sensor that big. These ultra-miniature current sensors sense current from 3 to 20 volts. Direct and alternating current (including pulse current) and current direction is detectable. These sensors are completely insulated against the secondary output. For a sensor the size of a penny, it is worth every one. CUI Stack: on top of it.

Contact Information:

Jim Seiler, VP, CUI Stack, 9640 SW Sunshine Ct., G700, Beaverton, OR 97005; Tel: 800-275-4899, ext. 11; Fax: 503-643-6129; E-mail: jseiler@cuistack.com

Circle No. 875 On Fax Form

Space-Age Sensors For Down-To-Earth Needs

New England Instruments has been manufacturing precision potentiometers, position sensors, and electromechanical assemblies since 1957. We are the acknowledged leader in conductive plastic potentiometer technology. Our products serve applications ranging from consumer appliances to military avionics. New England Instrument products convert physical parameters such as position and pressure into precise electrical signals that are used by system controllers or microprocessors, usually in feedback-loop mode operations.

Contact Information:

New England Instrument; Tel: 401-769-0703

Circle No. 876 On Fax Form



Novotechnik manufactures and distributes several families of linear displacement transducers, rotary position sensors, resistance elements, and custom-designed transducers. They feature outstanding linearity, high

tolerance to environmental extremes, long operating lifetimes (typically 100x10⁶ operations). Linear transducers offer electrical stroke lengths from 25mm to 400mm. Rotary potentiometers give 360° of mechanical rotation, and operational speeds to 10,000 rpm.

Contact Information:

Novotechnik; Tel: 508-485-2244 for a free catalog

Circle No. 877 On Fax Form



Patriot Sensors & Controls, Simi Valley, CA, introduces a new level of accuracy and reliability in precision pressure transducers for industrial use. Its SP200/210 Silicon on Sapphire Pressure transducers are offered in ranges of 0-100, 10,000

PSI with unparalleled absolute accuracy. With an absolute accuracy (maximum deviation from the ideal output within the operating pressure and temperature range) of $\pm 1.5\%$ FS, the SP210 sets a new engineering standard for true pressure transducer accuracy measurement.

Contact Information:

Colleen Morris, Patriot Sensors & Controls Corporation; Tel: 805-581-3985, ext. 129; Fax: 805-583-1526

Circle No. 854 On Fax Form



High-Precision Weight, Pressure & Acceleration Sensors

Setra Systems, Inc. is a leading designer and manufacturer of high-pressure weight, pressure, and acceleration sensing devices. Founded in 1967, Setra is comprised of two divisions. The Transducer Division supplies pressure sensing devices to HVAC/R, industrial, semiconductor, OEM, barometric, aeronautical, military, food, medical, and pharmaceutical markets. A complete line of pressure transducers and transmitters are available with full-scale pressure ranges from 0.1 in. H₂O to 10,000 psi with accuracy to 0.05%.

Contact Information:

Setra Systems, 159 Swanson Rd., Boxborough, MA 01719; Tel: 508-263-1400; Fax: 508-264-0292

Circle No. 882 On Fax Form



Setra Systems Inc.'s Weighing Systems Division provides load cells, counting/weighing scales, and balances to OEM, material handling, inventory control, and scientific measurement

markets, respectively. Load cell capacities range from 200 g to 50 kg and are accurate to 10 ppm. Circuits include a signal processing board with RS-232 interface and LED display. Setra employs variable capacitance technology in its entire product line. This award-winning, patented technology ensures the high level of accuracy and stability inherent in all Setra products.

Contact Information:

Setra Systems, 159 Swanson Rd., Boxborough, MA 01719; Tel: 508-263-1400; Fax: 508-264-0292

Circle No. 883 On Fax Form



Francis J. Kramer, President & Chief Operating Officer

For the past two years, our advertisements, literature, and annual reports have included the phrase, "Combining Excellence Across the Spectrum." At II-VI Incorporated, we feel that these words help convey the attitude and business philosophy of our growing organization. The word "Excellence" is basic to our goals, and expresses our dedication to quality in design, in manufacturing, and in service to our ever-growing customer base. "Across the Spectrum" helps describe the expansion of our product lines.

From our inaugural year of 1971 through 1994, II-VI Incorporated was dedicated primarily to infrared technology with products and services for industrial, commercial, military, and medical lasers covering the 2.0 to 20 micron wavelength range. Today, through internal product development, mergers, and acquisitions, the breadth of the II-VI Incorporated product offerings now includes products to serve the rapidly expanding solid-state laser markets through our VLOC subsidiary. Using our knowledge of CdTe-based compounds, we have seen our eV Products Division expand rapidly as it brings new technology to market in the field of gamma ray detector devices.

At II-VI Incorporated, special emphasis is being placed on research and new product development in the areas of electro-optical devices for use across a broad spectrum. We are providing high-end, high-specification components that meet our customers' requirements for optics and electro-optical devices from gamma ray to far infrared wavelengths.

II-VI Incorporated
375 Saxonburg Blvd.
Saxonburg, PA 16056
Tel: 412-352-1504
Fax: 412-352-4980
www.optics.org/ii-vi/

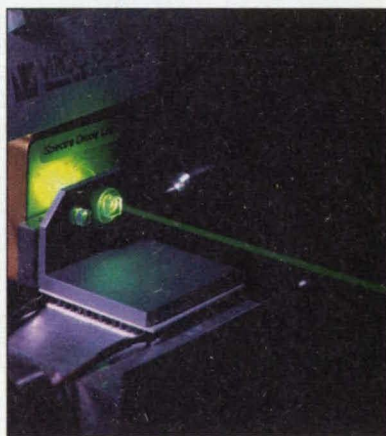
II-VI INCORPORATED

Material Growth Capabilities

Optics and optical components which meet or exceed specifications begin with the highest quality substrate materials. Complete understanding of the unique properties, preparation, and process control of these materials is critical. II-VI Incorporated is recognized worldwide as the leader in infrared crystal growth technology and the design and development of thin-film optical coatings.

Infrared Materials

- Zinc Selenide (ZnSe) - A fine-grained polycrystalline material, produced by chemical vapor deposition, superior for transmission for wavelengths of 0.5-14 microns. ZnSe offers excellent qualities for imaging due to



Green Light Emitter

- its homogeneous and uniform crystalline structure.
- Zinc Sulfide (ZnS) - Regular Grade - A mechanically strong, small-grained material has useful transmission in the wavelength range of 4-12 microns and offers exceptional hardness and flexural strength. This material is used exclusively in IR missile dome and FLIR applications.
- Zinc Sulfide (ZnS) - MultiSpectral Grade - Exhibits a high and uniform level of transmission from the visible through the infrared, making it particularly useful in FLIR systems requiring transmission at shorter wavelengths.
- Cadmium Telluride (CdTe) - An ideal substrate in the 2-25 micron region, where many materials have reduced or variable transmission due to the presence of absorption bands. Oriented single crystals of this compound also possess electro-optical properties, which make them useful in application of electro-optical modulation of IR light.
- Cadmium Zinc Telluride (CdZnTe) - Used

as a substrate for Epitaxial MCT (Mercury Cadmium Telluride) in the manufacture of IR focal-plane arrays. Using horizontal and vertical Bridgman techniques, ingots of up to 8kg are produced, yielding high-purity, single-crystal substrates up to 6 cm x 8 cm. In addition, our eV Products Division utilizes high-pressure Bridgman growth for production of CdTe/CdZnTe solid-state room-temperature radiation detectors.

Laser Gain Materials

II-VI Incorporated, through our VLOC subsidiary, offers a broad range of standard and custom laser gain materials and optics for industrial, scientific, and research lasers, including Nd:YAG and Nd:YLF. Produced to stringent specifications, these laser gain materials are precisely fabricated and coated per customer requirements. In addition, VLOC is a major producer of Cr:LISAF and Cr:LICAF crystals, which offer unique qualities as laser gain materials for solid-state lasers.

The VLOC subsidiary develops and produces nonlinear materials such as potassium niobate (KNbO₃) and potassium titanyl phosphate (KTP) used for the generation of laser light throughout the visible and near-infrared spectrum. Potassium niobate is particularly well-suited for efficient conversion of infrared laser light into the blue-green spectral region via second harmonic generation (SHG). Laser materials, components, and sub-assemblies produced at VLOC are used in efficient solid-state laser devices for the telecommunications, optical data storage, graphic display, and medical industries.

Contact II-VI Inc. for more information on infrared, near-infrared, visible and x-ray materials, optics, and electro-optic components. We're Combining Excellence Across the Spectrum.



Ultra-precision Diamond Machining Center

Circle No. 822 On Fax Form



Industry Leader for More Than Three Decades

Acton Research Corporation (ARC) is a leading manufacturer of high-performance laser optics, optical filters, multi-grating monochromators, and imaging spectrographs. The company was founded in 1960 to meet the increasing demand for high-quality optical products, and after a decade of pure research and development, ARC made its products commercially available. Our continuing emphasis is to offer the highest-performance and longest-lifetime optics and instruments available.

Precision Optics and Thin Film Coatings

ARC has built a strong international reputation for high-power laser optics, broadband mirrors, and precision optical filters. ARC excimer laser optics are used in thousands of laser systems, and also are incorporated into sophisticated semiconductor and medical



ARC is your source for high-quality excimer and UV laser optics, coatings, and filters.



Delivery of quality optical components is ensured by ARC's experienced Coating & Quality Control Technicians.

Acton Research Corporation
PO Box 2215
525 Main Street
Acton, MA 01720
Tel: 508-263-3584
Fax: 508-263-5086
E-mail: mc@acton-research.com
www.acton-research.com

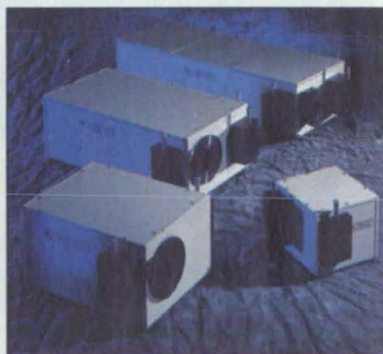
laser systems. ARC precision UV and VUV optical components are installed routinely in spaceborne experiments, including the Hubble Space Telescope service mission (Wide Field Planetary Camera), as well as various UV-based analytical instruments.

In addition to servicing the high-volume industrial OEM market, we also work closely with universities and government laboratories in the design of custom coatings and components. This ongoing dedication to improving the state of the art in optical tech-

nology has earned ARC the respect of professionals worldwide.

Versatile Monochromators and Spectrographs

Thousands of customers worldwide rely on the ruggedness, performance, and versatility of ARC monochromators and spectrographs, including the popular SpectraPro® Series instruments. Applications include optical emission spectroscopy, Raman, LIF (laser-induced fluorescence), plasma diagnostics, LED/laser diode characterization, and industrial process control. ARC monochromators and spectrographs undergo stringent quality controls and testing, including precision laser alignment followed by automated computer calibration to insure that every instrument meets or exceeds published specifications.



Industry-standard SpectraPro® multi-grating monochromators and spectrographs.

ARC Instrument Capabilities Include:

- Multi-grating monochromators and spectrographs from 0.150 to 3.0 meters
- Imaging spectrographs for CCD applications
- Measurement systems designed for VUV, UV, VIS, and near-IR applications
- Fast spectral data acquisition systems with dedicated spectroscopy software
- Complete selection of light sources, detectors, and spectroscopy accessories

Leading-Edge Applications

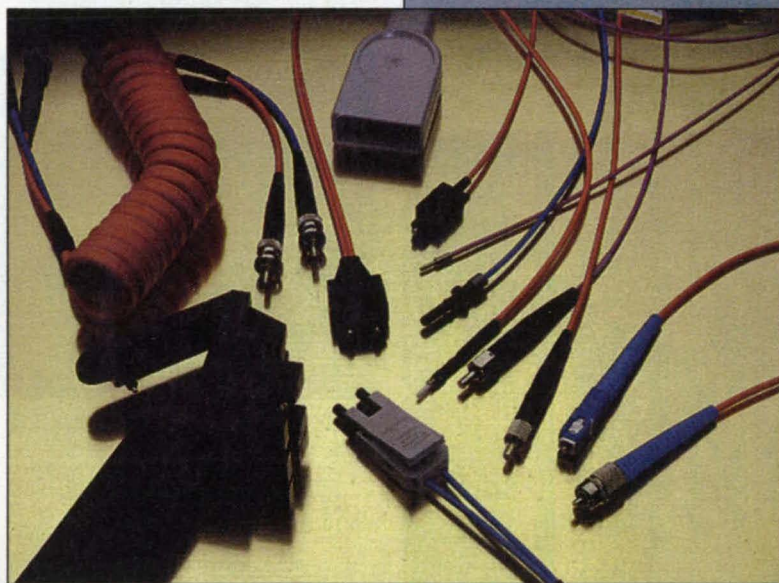
Today, ARC products are used in nearly every major industry incorporating optical or electro-optical technologies, including medical, semiconductor, laser, analytical chemistry, spectroscopy, aerospace, high-energy physics, basic and applied research, education, and OEM markets.

Circle No. 835 On Fax Form



For more than a decade, SpecTran Specialty Optics Company has been a world leader in engineered fiber optic solutions for the communications, industrial, medical, and military markets. SpecTran Specialty Optics is a proud contributor to multiple NASA and Air Force high-technology programs. Recently, SpecTran Specialty designed and manufactured a hermetically sealed, bend-insensitive, radiation-hard fiber optic cable that meets stringent aircraft performance requirements. This cable, FLIGHTGUIDE™, is now a standard for space and aviation applications.

SpecTran Specialty Optics Company, as well as all subsidiaries of SpecTran Corporation, utilizes the resources of corporate research personnel and facilities for advanced



ers result in developed fiber optic solutions that meet NAMSA and Class VI biocompatible standards for critical devices such as laser surgery and blood gas monitoring. Final assembly, packaging, and sterilization are performed in Class 10,000 clean rooms.

...In the Sky and on the Ground SpecTran Specialty's products meet unique customer requirements ranging from high data communications on advanced tactical aircraft, to power transmission for initiation of pyrotechnics on next-generation launch vehicles and aircraft ejection seats. SpecTran Specialty Optics Company's FLIGHTGUIDE™ and AVIOPTICS™ cables are aerospace-industry standards and baselined today on programs such as the F-22 Advanced Tactical Fighter and the Comanche helicopter.

SpecTran Specialty Optics Company excels at solving tomorrow's technology problems today. Let us engineer your solution!

fiber optic solutions. SpecTran Specialty Optics manufactures high-strength, high-performance, specialty single-mode, multimode graded-index, and step-index products. SpecTran Communication Fiber Technologies, Inc., is a world-known producer of single-mode and multimode graded-index fiber. Together, SpecTran Corporation and its subsidiaries provide high-performance products that precisely match customer applica-

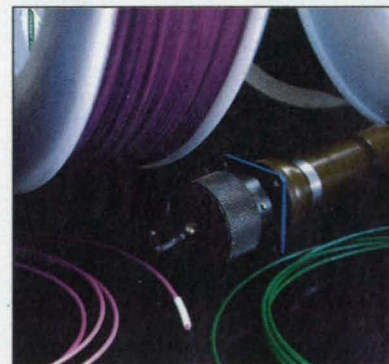
tion requirements. This year, SpecTran further reinforced its commitment to world-class quality products and services with Bellcore ISO-9001 certification.

Products and Applications

...On the Information Superhighway SpecTran Specialty Optics' specialty single-mode products are used extensively in fiber couplers and WDM systems supporting multigigabit systems.

...On the Factory Floor HCS® (Hard Clad Silica) products are durable, quick and easy to terminate, and are an integral part of the link between independent computers, PLCs, and I/O devices where high reliability and ease of installation are important requirements.

...In the Operating Room Strategic partnerships with medical equipment manufactur-



SpecTran Specialty Optics Company
P.O. Box 1260
Avon, CT 06001-1260
Tel: 860-678-0371
Fax: 860-674-8818
E-mail: ssocfiber@aol.com

Circle No. 836 On Fax Form

Synrad

Synrad, Inc. was founded in 1984 by Peter Laakmann to do advanced research in electro-optics and expand on his RF-excited CO₂ laser technology, which he had developed originally in an earlier venture. Initially located in Southern California, Synrad conducted experiments with radio frequency (RF) excited plasma, the results of which made it possible to manufacture high-quality, sealed CO and CO₂ lasers at reduced costs. In 1986, Synrad changed location to a more modern production plant north of Seattle, and began producing thousands of laser tubes per year. In the first ten years, Synrad grew to its current status as the recognized world leader in manufacturing sealed CO and CO₂ lasers with powers between 10 and 240 watts. Laser applications include cutting, marking, drilling, heat-treating, sealing, and engraving of some metals and most non-metal materials.

Synrad builds RF-excited CO and CO₂ lasers based on a family of optical, mechanical, and electronic modules that enable the company to develop and market lasers from common parts. The 10-watt laser is the basic building block, consisting of a sealed CO₂ plasma tube, an RF driver module, a control circuit, and a chassis and heat sink to assemble all of the above.

The 25-watt laser uses a plasma tube twice the length of the 10-watt, and the DuoLase™ series of lasers combines two of the 25-watt tubes to produce a single laser beam using the laser's natural linear polarization. This method delivers twice the power in a chassis of about the same length.

Most metal components used in production are aluminum extrusion, which is lightweight, durable, and compatible with laser operations. Synrad's patented "all metal" technology allows for mass production at low

costs. Therefore, the company can offer superior-quality sealed CO₂ lasers at a fraction of the price of competitors. That affordability of Synrad lasers has boosted sales into an average growth rate of over 65 percent for the past three years.

The primary business objective of Synrad is to supply the highest-quality component-level lasers and accessories for use as is or incorporated into OEM systems. The low cost, durability, and simplicity of Synrad's products makes owning and operating a laser-based system practical and economical

currently developing the 500W Excalibur CO₂ laser for high-power materials processing applications.

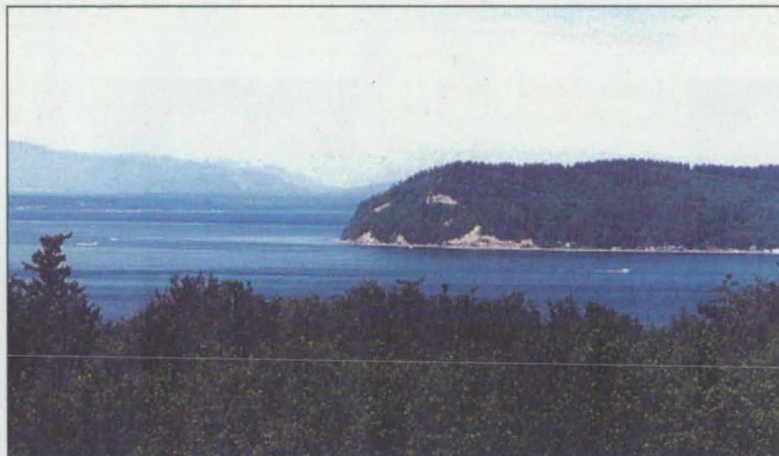
Synrad's expanding market includes industrial users of inexpensive, high-quality, and user-friendly "component-level" lasers. Typical applications are engraving or cutting plastic, paper, wood, and textiles, as well as marking of anodized aluminum. An increasing number of marking applications are now found in automated production lines and small-scale consumer applications.

Synrad's primary customers are OEMs

that build and sell instruments to service the above markets. However, scientific and R&D labs are proven long-standing and equally valuable customers. The proliferation of personal computers has given a boost to the use of sealed CO₂ lasers for such tasks as "desktop manufacturing" in connection with computer aided drafting software. The three-

dimensional computer-driven rapid prototyping technology promises the same for "hands-off" model-making using the laser and a personal computer.

Synrad's rapid growth necessitated further expansion, in the spring of 1996, to a building in Mukilteo, WA, that is nearly three times the size of the previous facility. The additional space has allowed for increased production, more lab space for new product development, and a rapidly growing employee roster. In 1992, Synrad employed less than 25 people. Currently, Synrad employs a staff of approximately 110. With a company policy of customer satisfaction and growing domestic and international markets, Synrad forecasts continued growth through the end of the century.



View of Puget Sound from Synrad's new Mukilteo facility

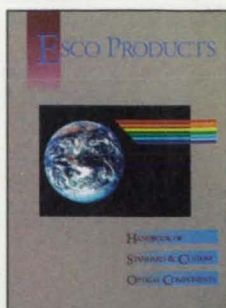
for a wide range of businesses without the need for a dedicated laser technician or in-depth laser knowledge.

Synrad has continued to increase its customer service orientation by offering the convenience of an expanded product line. Along with CO and CO₂ lasers in the 10- to 240-watt range, Synrad offers compatible DC power supplies, laser power meters and probes, laser safety glasses, visible laser diode printers, selected focusing lenses and beam delivery components, and expert laser service.

The latest developments from Synrad include the SH Series of marking heads and the ever-popular Power Wizard (PW-250 and PW-2) pocket-sized laser power meters that improve upon the traditional "meat thermometer" power probes. Synrad is cur-

Synrad, Inc.
6500 Harbour Heights Plwy.
Mukilteo, WA 98275
Tel: 206-349-3500
Fax: 206-485-4882

Circle No. 837 On Fax Form



ESCO Products is a manufacturer of precision optics. We maintain an inventory of catalog optics, which are available off the shelf or with short lead times. Custom requirements also can be met in prototype or production quantities. All of these are described in our Handbook of Custom & Optical Components.

Contact Information:

ESCO Products; Tel: 800-922-ESCO (3726); Fax: 201-697-3011

Circle No. 863 On Fax Form



Laser-Based Structured Light Projectors

Lasiris Inc. is offering a complete line of eye-safe Laser-Based

Structured Light Products for machine vision and alignment. Featured are focusable line generators from single line to 99 parallel lines of a uniform, non-Gaussian distribution of intensity, circle, and concentric-circle projectors; dot, line, and dot matrix projectors; and a new crosshair projector using only one laser and a unique patented optic. Laser heads are also interchangeable.

Contact Information:

Lasiris Inc., 3549 Ashby, St-Laurent, Quebec, Canada H4R 2K3; Tel: 514-335-1005 or 800-814-9552; Fax: 514-335-4576

Circle No. 886 On Fax Form



Laser Diode Optics

Optima's off-the-shelf optical components are geared for today's laser diode applications. Our new brochure includes collimating and objective lenses (glass and plastic), diode laser modules, line generating modules and lenses, laser diode mounting kits, collimated diode lasers,

infrared filters, anamorphic prisms, two-axis and four-axis positioners, and accessories.

Contact Information:

Optima Precision Inc., 775 SW Long Farm Rd., West Linn, OR 97068; Tel: 800-544 4118; Fax: 503-638-4545; E-mail: optima-prec@worldnet.att.net; Web site: <http://www.optima-prec.com>

Circle No. 864 On Fax Form



24-Hour Delivery: Off-the-Shelf Optics

Free 130-page product catalog from Rolyn, world's largest supplier of off-the-shelf optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces, plus thousands of other stock items. Rolyn also supplies

custom products and coatings in prototype or production quantities.

Contact Information:

Rolyn Optics Co., 706 Arrow Grand Circle, Covina, CA 91722; Tel: 818-915-5707; Fax: 818-915-1379

Circle No. 865 On Fax Form



A New Level of Performance in Night-Time Digital Imaging!

Electrophysics has introduced an absolutely new night vision module that transforms dark, moonlit, or starlit nights into bright, high-resolution scenes that are easily recorded by the Electronic Camera System host. The new patent-pending design results in the absolute highest possible night-time imaging performance available for digital and SLR cameras and camcorders. Because of its modular design, the AstroScope is powered by the electronic camera and accepts the same electronic lenses that were intended to be used with the camera.

Contact Information:

Electrophysics Corp., 373 Route 46 West, Bldg. E, Fairfield, NJ 07004; Tel: 201 882-0211; Fax: 201-882-0997

Circle No. 881 On Fax Form



Hitachi Denshi has further expanded its family of KP-M Video Cameras for imaging systems. The line now contains 2/3", 1/2", and 1/3" CCD sensors. The KP-M Series also includes right angle viewing and two-piece configurations. Hitachi's KP-M Cameras are available in 525 line EIA and 625 line CCIR formats. Hitachi Denshi has one of the broadest selections of video cameras for imaging use, including 3-CCD and 1-CCD color, progressive scan, and black and white mega-pixel cameras.

Contact Information:

Hitachi Denshi America, Ltd., 150 Crossways Park Dr., Woodbury, NY 11797; Tel: 516-921-7200; Fax: 516-496-3718

Circle No. 880 On Fax Form



1996 Emmy Award Winner For Lens Technology

Long recognized as the technological leader in advanced optical systems, Canon U.S.A.'s Broadcast Equipment Division (BCTV) has been awarded the prestigious 1996 Emmy for "Outstanding Achievement in Technical/Engineering Development" and specifically for "Implementation of Lens Technology to Achieve Compatibility with CCD Sensors."

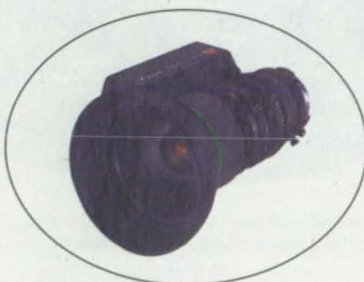
This outstanding level of technology can be found in the innovative, versatile, and unique products described here.

Canon

Optical Image Stabilizer, Vari-Angle Prism Lenses

Canon's Optical Image Stabilizing Lenses utilize Canon's innovative Vari-angle Prism technology to virtually eliminate image shaking due to any type of high-speed movement, vibration, or high wind conditions. These VAP lenses include Canon's J14aX17B KRS-V for telephoto applications, the J13aX9B KRS-V for wider angle applications, and the IS-20B Adapter for use with the J20aX8B broadcast quality lens.

When image shaking occurs, the vibration sensor sends a signal in proportion to the degree of shaking. The signal is processed by the microcomputer and passed to the prism drive actuator, which adjusts the prism angle as needed to compensate for shaking. While the image stabilization system is operating, the prism is constantly monitored by the prism angle sensor, allowing real time control over the prism.



Canon's YJ 17X9.5B KTS A lens

Multi-Use, High-Quality Industrial Video Lenses

The worldwide leader in broadcast television lenses, Canon remains committed to engineering the best lenses in their class, while providing real solutions for the broad range of high-quality industrial video user needs, including machine vision, line inspection, sorting by color, automated or unattended operations, and R&D.

Canon's superior quality video communication lenses include the YJ17x9.5 KTS A, the YH17x7 KTS A and the YH13x7.5 KTS A, and feature advantages such as super close-up, 17X zoom capability (found in the YJ17 and YH17), fast and quiet servo operations, and other benefits normally associated with Canon's world-class high-quality broadcast video lenses.

KTS lenses can be used with most any 2/3" or 1/2" camera and offers remote control zoom, focus and iris functions available via our TCR-101F, 201F, or 301F line of controllers. Lightweight and sturdy, these lenses



Canon's J13 and J14 VAP lenses

are also available with a simple interface for use with custom-designed controllers.

Canobeam II Optical Beam Transmission System

Canobeam II is a highly reliable Optical Beam Transmission System that features speed, bi-directional bandwidth and a new Auto-Tracking system for uninterrupted FDDI, ATM/OC3 transmission where no optical cable exists.

Airports, nuclear power plants, and other locations unsuitable for ground-breaking construction can take advantage of FDDI, ATM/OC3. And, because Canobeam II operates "optically" and interference-free, reliable and confidential transmission is assured.

Canobeam II is engineered for maximum safety, even when viewed directly, and operates in accordance with international laser safety standard IEC825. No FCC licensing is required to operate Canobeam II.

Canobeam II is easy to use and install and features interchangeable module units for FDDI or ATM/OC3 use. Canobeam II is capable of transmitting at speeds of 125/155 Mbps at a distance of 2.5 miles. A built-in "video camera" feature automatically sets up the bi-directional HS-40B Heads, while the CD-30F unit, which is attached by two coaxial cables, provides control and monitoring from any location.



Canon's Canobeam II

Canon U.S.A.
Tel: 800-321-4388
www.usa.canon.com

Circle No. 847 On Fax Form

Inframetrics: The Infrared Specialists

Leadership Based on Performance

Inframetrics is a world leader in the design and manufacture of infrared (IR) thermal imaging and measurement systems. Since its founding in 1975, the company has introduced a broad range of new products based upon continuing innovation and proven performance to help you save time and money, develop new products or quality-control existing ones, plan maintenance costs effectively, and monitor system conditions. Inframetrics continues to pioneer, advance, and refine IR technology. Rugged and reliable, Inframetrics systems adapt to virtually any application and environment where precise thermal measurement and monitoring are required.

Today, an array of Inframetrics' user friendly IR systems are being applied in such diverse fields as: predictive maintenance, product research and development, aerospace research, non-destructive evaluation, process monitoring and control/QC, electronics design and manufacturing, non-invasive medical assessments, navigation, search and rescue, ground and airborne surveillance, law enforcement, and in the military.

A focus on real-world research, applications engineering, customer training, and highly responsive on-site field applications support has built a customer loyalty for Inframetrics unmatched in the infrared industry.

ThermaCAM®: The World's Best-Selling IR FPA Temperature Measurement System

The company offers a diverse line of products, each distinguished by powerful performance capabilities and broad utility. Their

held focal plane IR measurement systems.

The refinements in the Series II ThermaCAMs will further boost the market's acceptance of a product line that already has become the world's best-selling range of industrial FPA thermal imaging systems. Refinements to the design were a result of customer feedback and technological advancements since the original introduction of the product line in March of 1995.

The new product range consists of four models, three designed for the predictive maintenance market and one, the Model SC1000, designed for the scientific community. This camera offers the accuracy and sensitivity demanded by scientific applications while providing the portability and imaging performance associated with FPAs. The SC1000 includes a real-time 12-bit digital output and provides the analysis power associated with workstation-based systems, but has the flexibility of a handheld camera and of Windows 95 processing environment.



ThermaCAM® family of FPA infrared imaging and temperature measurement systems.

newest line of infrared systems, the ThermaCAM® II Series, represents further advancement in the state of the art in hand-



Gathering data from design changes can be done right in the field. Thermal image of disk brake rotor shows heating pattern of brake pads.

Inframetrics, Inc.
16 Esquire Road
North Billerica, MA 01862
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E-mail: info@inframetrics.com
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Circle No. 828 On Fax Form



VISION

Seeing is Believing With n-Vision Display Products

In Maryland, a group of cardiologists dons helmets and feel as if they have been miniaturized and injected into the left atrium of a patient's heart. In Pennsylvania, an auditor uses a similar system to create and access three-dimensional spreadsheets. In Sweden, an engineer working on the design for a 21st-century Volvo checks performance characteristics in a virtual reality simulation; in Germany, prospective clients test-drive a simulated Mercedes-Benz on a virtual Autobahn.

The effectiveness of the virtual reality experience depends greatly on the quality of the system's visual display components. The experience is believable if and only if the display convinces users to accept the reality of what they think they see.

At NASA, at the U.S. Departments of Defense and Energy, and in the design studios of dozens of key industries, ideas are being transformed to realistic simulations displayed on devices produced by n-Vision, a new-era, high-technology firm based in McLean, VA. Industrial designers, aerospace engineers, medical innovators, and other pioneers around the world rely on n-Vision displays to help them visualize their concepts in ways that, just a few years ago, could only be fantasized about.

Datavisor Display System Sets the Standard

As the virtual reality industry's premier designer and producer of immersive display systems, n-Vision has become a vital and valued player. Their devices have established the standard for high-resolution, realistic

excellence. Leading-edge virtual reality installations throughout the world rely on n-Vision technology and products for these key components.

Founded in 1988, n-Vision came to national prominence when it won a NASA contract to develop a miniature display system for use in the High Alpha aircraft cockpit design program. In 1991, at the conclu-



Virtual Binoculars



Datavisor

cations with high-end needs that require cost-effective solutions.

The Datavisor line continues to expand. It now includes the Datavisor 80 (with a spectacular 120-degree field of view), as well as solutions ranging from high-resolution devices to VGA models that feature nearly universal system compatibility.

Virtual Reality - Real Markets

Today's n-Vision products and custom development services provide serious solutions for many rapidly growing markets. Both the Datavisor family of head-mounted displays and the firm's handheld "Virtual Binoculars" are systems of choice for both the mid-priced and high-end sectors of the virtual reality industry. From industrial research to defense training, n-Vision has set the standard and continues to lead the technological advancement of virtual display devices.

Products created and manufactured by n-Vision also are distributed worldwide through resellers in the U.K., Germany, and Japan. For more information, visit the n-Vision home page at: <http://www.nvis.com>.

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www.nvis.com

Circle No. 848 On Fax Form

Videographic Products for Advanced Applications

Since its founding in 1986 RGB Spectrum has grown to be a technology leader dedicated to the integration of computer, video, and infrared signals for display and communications. Applications include command-and-control, simulation and training, multimedia display, videoconferencing, surveillance, remote video monitoring, unmanned-vehicle communications, visualization, television broadcast, and virtual reality.

RGB Spectrum provides an extensive range of products to integrate computer and video signals. Products are offered in both standalone and board-level configurations for the widest possible compatibility with computers and workstations of all types. Capabilities include video scan conversion, video windowing, multiscreen display, image fusion, and computer signal synchronization.



Kollsman Inc.'s gunnery trainer for the TOW (Tube-launched Optically-tracked Wire-guided) missile. The system uses a SynchroMaster 100 color field-sequential scan converter from RGB Spectrum to provide real-time conversion between the RGB signals from the computer and the color field-sequential signals required by the monitor. (Photo courtesy Kollsman, Inc.)

Product lines include:

- The RGB/Videolink® scan converters that transform high-resolution computer graphics to broadcast-video format in real time. Output options include NTSC, PAL, S-Video, CAV, CCIR601, digital video, and 31.5-kHz RGB for projection. The RGB/Videolink features a zoom, flicker elimination, and graphics overlay on video.

RGB Spectrum
950 Marina Village Parkway
Alameda, CA 94501
Tel: 510-814-7000
Fax: 510-814-7026
E-mail: sales@rgb.com
www.rgb.com



The RGB/View and SuperView video windowing systems allow users to combine a high-resolution workstation screen with multiple live video windows. Here, four simultaneous real-time video signals are being shown on a computer monitor.

- The Videolink HD™, a unique recording system for high-resolution computer imagery. By working with the latest in HDTV recorders, the Videolink HD is able to record high-resolution (up to 1280 X 1024) computer signals at the HDTV 1125-line standard, double the number of lines resulting from ordinary video-scan conversion.

- The RGB/View® and SuperView™ video windowing systems, which display multiple simultaneous real-time video windows on high-resolution monitors, projection cubes, or other data-display devices. Inputs may include NTSC, PAL, S-Video, FLIR, other



Southern California Edison's Moorpark Substation is a state-of-the-art command center and a working prototype for future upgrades of the company's transmission substation control systems. This photo shows a 2-X-2 video wall controlled by RGB Spectrum's ComputerWall multiscreen processors. (Photo courtesy American Video Communications)

computer signals, etc. The windows can be positioned, scaled, and overlaid with computer graphics. Available as a standalone peripheral or a 6U VMEbus card.

- ComputerWall® is a multiscreen display controller that creates a "wall-sized" computer display by magnifying and splitting computer images across an array of 4 or 16 projector screens. It is compatible with all computers up to 1280-X-1024 resolution and displays images in real time.

- The SynchroMaster® 300, a synchronizer, switcher, fader, and dissolve unit for data-display projectors. It can superimpose one computer image onto another, combine asynchronous images of similar resolutions, and mix interlaced and noninterlaced images.



Sensors embedded in Los Angeles freeways communicate with a CALTRANS workstation to produce this map, which shows current freeway speed represented by colored lights. Using RGB Spectrum's RGB/Videolink scan converter, CALTRANS converts the high-resolution computer screen to NTSC, and broadcasts this map via cable TV to 500,000 homes in Los Angeles. (Screen image courtesy CALTRANS [State of California Dept. of Transportation])

- The SynchroMaster 100, a color-sequential video scan converter that converts between color-parallel and color-sequential signals, to interface computers and scene generators with helmet-mounted and other VR displays using color shutter technology.

RGB Spectrum products are distributed internationally. The company is headquartered in Alameda, near San Francisco, CA.

Circle No. 849 On Fax Form

12-Bit Accuracy With an 8-Bit Digitizer

Spiricon has developed a new high-technology framegrabber card and associated software. This framegrabber card and software, Model LBA-300PC, was optimized for laser-beam analysis, but has potential usefulness in many other applications. As shown in Figure 1, a laser beam is composed of a signal that contains intensity information far out into the wings of the beam. Because this signal is of very low intensity, but critical in beam-width measurements, it is essential that the baseline or background of the camera be correctly adjusted. If not accurately set, or if the random noise from the camera is not properly compensated for, then inaccuracies in measuring the beam width are encountered. There may be many other applications wherein the precise baseline of a CCD camera imaging system must be compensated for correctly.

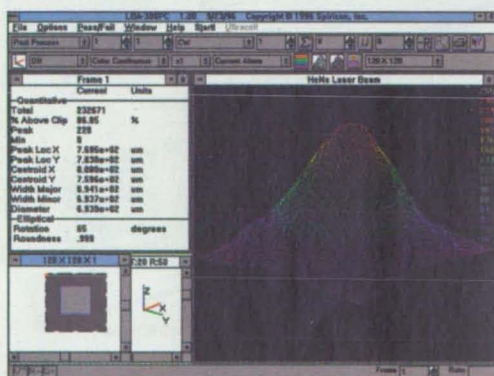


Figure 1. LBA-300PC beam-profile display showing a laser beam with low-intensity energy out into the wings of the beam.

In the past, researchers have used expensive 10- and 12-bit cameras and digitizers to obtain the accuracy needed for demanding applications. However, even these do not necessarily compensate correctly for the baseline offset and noise in the camera-digitizer interface. With an inexpensive 8-bit digitizer, the new Spiricon hardware and software can give accuracies similar to that obtained by 10- and 12-bit systems in some applications.

Spiricon, Inc.
2600 North Main
Logan, UT 84321
Tel: 801-753-3729
Fax: 801-753-5231
www.spiricon.com

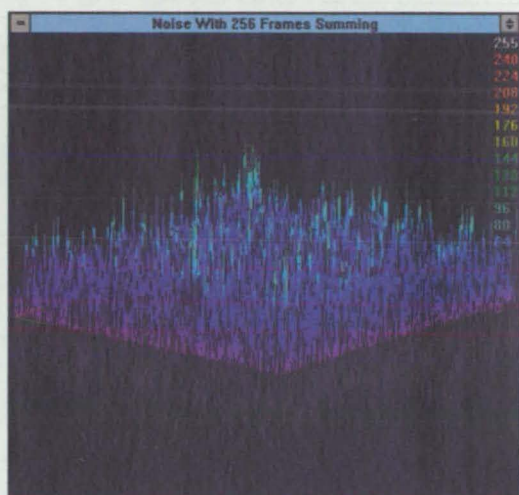


Figure 2. 3D view of random noise readout from camera after summing 256 frames.

Patented Algorithms for Precise Baseline Offset and Noise Compensation

The LBA-300PC framegrabber and software enable automatic setting of the precise baseline. In addition, the system accounts for both negative and positive noise components of the camera. Without the negative noise components that are truncated by most digitizers and by "background subtraction," the remaining positive noise components can distort measurements.

Also, without retention of the negative noise components, summing would cause a net positive drift in the DC bias. The LBA-300PC system uses a 16-bit frame buffer to keep track of both positive and negative noise.

To measure the accuracy of the baseline setting, the LBA-300PC software was set to Sum 256 frames with all light input to the camera blocked. Figure 2 is a 3D plot of the camera output, showing the noise frame obtained after this summing. Shown are the positive noise components going through the colors and the negative noise components in gray. Summing was used to increase the noise to a level that enabled statistical analysis. In operation, summing is a technique that could be used to extract weak signals

buried in the noise, since the signal sums as the number of frames, and the noise sums as the square root of the number of frames. Figure 2 gives a visual perspective that the noise is random and roughly centered about zero.

Figure 3 is a histogram of the noise of Figure 2, created by the LBA-300PC software. It shows the number of pixels that are recorded at each digitizer level. A numerical analysis of the data of Figure 3 shows that it is Gaussian, and the center is less than 1/5th of a digital count from zero. Thus, since the Sum is 256 noise frames, the accuracy of setting the baseline to zero is 0.2/256, or better than 0.1 percent.

The LBA-300PC software enables additional features that could be useful for many applications. For example, the display scale can be increased by 2, 4, 8, or 16 in the software. The user is then able to adjust which intensity levels are viewed over the dynamic range of the display. This is the equivalent of software "signal contrast enhancement."

There are many other features of the new framegrabber and software that may prove useful, both for laser-beam analysis and for other applications.

A free copy of a demonstration version of the software is available on Spiricon's web page: www.spiricon.com, under "Product Data/Free LBA-300PC Software."

Figure 3: Histogram of noise from camera after 256 frames of summing. The plot shows a Gaussian distribution of noise levels with a color scale on the right ranging from 0.0 to 1.00.

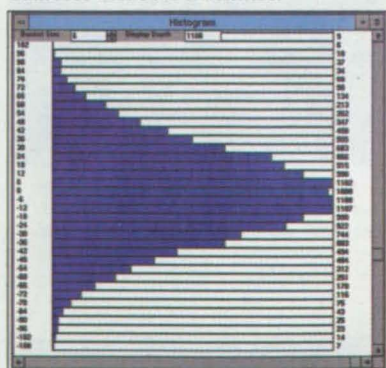


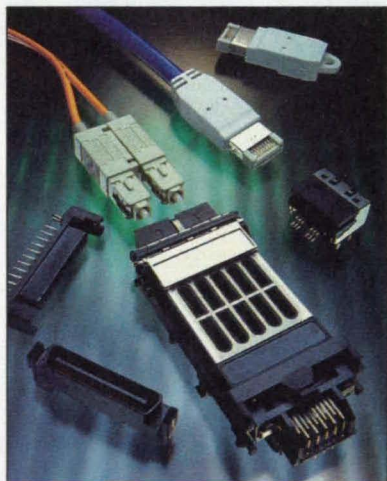
Figure 3. Histogram of noise from camera after 256 frames of summing.

Circle No. 850 On Fax Form

Connecting at a HIGHER level.™

As a leader in interconnection technology, AMP provides end-to-end engineered solutions for high-speed interconnections. For the digital logic designer and packaging engineer, high-speed interconnection design presents many demanding challenges. Rather than developing competencies in such specialty areas not necessarily strategic to their business, leading companies are concentrating on what they do best, and partnering with companies that bring engineered solutions and add value to their design. Companies like AMP.

This is one element of what we call Connecting at a Higher Level. A premise of this concept is that in a high-speed device, everything from the IC to the I/O is part of the interconnection system, and must be engineered on an electronic level for optimum performance. From design validation by computer simulation and analysis to manufacture of interconnect components and subsystems, AMP offers a full spectrum of products and services to provide interconnection systems that perform to specification.



In addition to design and assembly of complete interconnect systems for high-speed data, AMP provides copper and fiber components, including connectors, cables, and cable assemblies.

AMP Incorporated
Harrisburg, PA 17105-3608
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AMP

Complete Interconnection Solutions for Fibre Channel

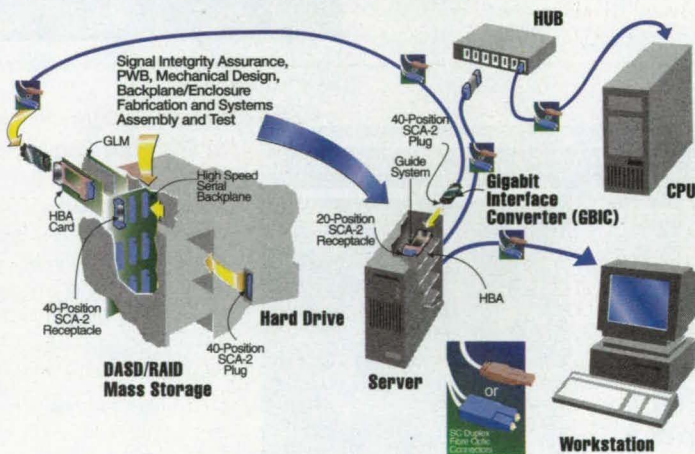
The complete interconnection solution for Fibre Channel is a good example of "Connecting at a Higher Level." In addition to connectors, cable, and cable assemblies, the Fibre Channel interconnect offering from AMP includes design simulation and analysis services, manufacture of high-performance multi-layer boards, and assembly services. Fibre Channel arbitrated loop, point-to-point, and switched topologies at speeds up to 1.062 Gbps are accommodated by AMP interconnection solutions.

tion, and EMI management.

High-Speed Serial Data Connections accommodate serial transfer rates up to 2.125 Gbps on copper cable for 30 meters or more. Approved by the ANSI X3T11 committee for Fibre Channel, the system also is being considered by ANSI X3T10.1 for Serial Storage Architecture and by IEEE 802.3 for gigabit Ethernet. HSSDC plug and receptacle connectors offer a high-density, controlled-impedance, fully shielded system.

SCA 2 connectors include 40-position ver-

Fiber Channel Interconnect Solutions



From system simulation and high-performance backplanes through interbox cable assemblies, AMP offers comprehensive solutions to Fibre Channel connectivity.

Sophisticated modeling and simulation are the basis for design analysis to predict, validate, and optimize system performance. Such verification helps ensure signal integrity by predicting impedance, crosstalk, ground bounce, noise budgets, and other critical parameters. One result is prototypes that work as predicted, helping customers get products to market faster.

Fibre Channel backplanes. AMP is a leader in the design and manufacture of high-performance, multi-layer PC boards. We design, layout, manufacture, and populate boards that meet demanding space, performance, and cost objectives.

Assembly services include the design and assembly of backplanes, card cages, cables, and other assemblies. Our design services address thermal management, power distri-

sions for direct-connecting disk drives to Fibre Channel backplanes and 20-position versions for the gigabit interface connectors used on Fibre Channel hubs, switches, and host bus adapters.

SC connectors for optical fibers, in simplex and duplex single-mode and multi-mode versions, allow users to achieve the maximum distance capabilities of Fibre Channel.

Cable and cable assemblies for all Fibre Channel copper and fibre interconnection needs. AMP is a major manufacturer of copper and fiber optic cable and cable assemblies.

Circle No. 801 On Fax Form

OMRON®

Applying Technology for Advanced Control Solutions

Mission

Omron Electronics, Inc. uses control systems and devices of its own design and manufacture to provide advanced solutions for factory automation and electronic components for commercial and consumer products. Omron offers more than 20 years of experience integrating design, installation, and support of customer systems and meeting standards for efficient global coordination of manufacturing.



Omron provides multi-location and national account coordination from U.S. headquarters, exclusive inventory arrangements, customized testing reports to eliminate incoming inspections, custom bar coding, next-flight-out emergency shipment of parts.

Sales and Support Facilities

America's headquarters for Omron are in Schaumburg, IL. Omron Canada in Scarborough, Ontario, and Omron Brazil are subsidiaries. Visit our FA Plaza Technology Showrooms in the U.S. and Canada. Training facilities are located in Schaumburg, Toronto, regional U.S. offices, and at certified distributors. Omron manufactures relays, photoelectric sensors, and other controls at Omron Manufacturing of America in St. Charles, IL. Our R&D centers are located in Japan, Singapore, U.K., Netherlands, Germany, and the U.S.

Omron Electronics, Inc.
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Key Data

Omron Corporation 1995 revenues were \$5.6 billion. Omron employs 23,000 worldwide. There are 55 international subsidiaries and more than 40 factories worldwide, all with ISO 9000 certification. Omron was founded in 1933 in Kyoto, Japan. Omron Electronics, Inc., responsible for North American marketing, was started in 1973. It employs 700 divided among 34 branches and regional offices, training facilities, and application labs.

Products

- Relays - low signal, PCB, and general purpose
- Switches - snap action, keypad, thumb-wheel, DIP, rotary
- Photomicrosensors
- Magnetic card readers - insert, swipe, motorized
- Radio frequency and bar code data handling systems
- Machine vision systems
- Programmable controllers
- Photoelectric & proximity sensors, limit switches
- Timers, counters, panel meters, power supplies
- Measurement sensors
- Operator interface terminals
- Process & temperature controllers
- Software for PLCs, process control monitoring



Control Components include relays, switches, small optical switches and sensors, and card readers. For a CC Standard Products Catalog, fax 847-839-2345 or e-mail CC@oel.omron.com.

Recent Advances

Surface-mount and through-hole low-signal relays with identical internal construction and high-precision lead pitch for more efficient auto-insertion.

Surface-mount and through-hole miniature touch switches for keypads and joysticks.

Background-suppressing miniature photoelectric sensor detects overhead transparency film and paper.

Microdisplacement sensor with analog output designed for check-clearing, but has found application in measuring cracking and movement in National Park Service monuments.

Off-line circuit board inspection system uses color vision to provide 3D views of solder joints, captures defect views, records data/time to reduce time and operator fatigue in quality control process.



Factory Automation controls and systems that are simple to integrate include machine vision, RFID and bar code data handling systems, programmable controllers and operator interface terminals, software, DeviceNet components, process and temperature controllers, timers, counters, and panel meters. For a Short-Form FA Catalog, fax 847-839-2345 or e-mail FA@oel.omron.com.

A single Windows-based programming software for all Omron PLCs.

RF-based data handling system encodes batch and routing data onto industrially hardened tags for read/write access to data at the point of use.

Ethernet gateway for mid-sized PLCs on a plug-in PCMCIA card.

CMP1 micro PLCs for 10-50 I/O point applications.

Machine vision systems with optical character recognition (OCR), gray scale resolution to handle high-speed, multi-camera inspection.

CV-Series programmable controllers provide transparent, multi-level communication within and between networks.

See Omron's products in action by visiting the Factory Automation Plaza Technology Showroom in Schaumburg. Fax a visit request to 847-839-2345.

Circle No. 811 On Fax Form



Brian Joseph, Executive Director

Each morning thousands of scientists and engineers leave their homes and families to invent the future at research facilities across America.

About 20 percent of those researchers head for the more than 700 federally-funded laboratories like NASA's Johnson Space Center or the Department of Energy's Lawrence Livermore National Laboratory.

The work of the more than 100,000 federal researchers who have produced more than \$36 billion in federally-sponsored research is available to U.S. companies with ideas they want to turn into products. And access to all this information has one comprehensive entry point: the National Technology Transfer Center.

NTTC is home of NASA TechTracS and the largest repository of federal research and development information available to the public. Call 800-678-6882 or visit <http://www.nttc.edu> for more information about how you can gain access to the expertise, facilities, and technologies of those federal researchers.

Public- and private-sector partnerships can strengthen the U.S. economy. Companies become more competitive in today's global market because they do not have to apply precious resources to research that already may have been accomplished.

NTTC can help you find a match. Call us.

National Technology Transfer Center (NTTC)
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Wheeling, WV 26003
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Fax: 304-243-2457



NTTC Products and Applications

NTTC enhances U.S. industry's economic competitiveness by facilitating commercialization of NASA and federal technologies.

NTTC's National Gateway links business to vast NASA and federal technological resources by calling 800-678-6882 or visiting <http://www.nttc.edu> on the World Wide Web. Technical experts in many specialties search NASA's TechTracS and the most complete set of databases for federally-sponsored research and development to help callers find the researchers, technologies, and facilities within the federally-sponsored R&D system that most meet their needs.

NTTC administers TechTracS, the NASA Technology Tracking System. TechTracS is NASA's primary tool for managing its commercial resources. Access TechTracS via its search application, TechFinder, on the World Wide Web at <http://www.ntas.nttc-nco.edu>.

NTTC concentrates on preparing technology transfer professionals for their work with businesses through its technology commercialization and innovation management training opportunities.

NTTC's training activities include the National Industrial Extension Agents Curriculum and projects with NASA's Office of Space Access, U.S. Navy's Office of Naval Research, the

Environmental Protection Agency, and the Department of Commerce's Entrepreneurial Technology Apprenticeship Program.

NTTC conducts national outreach and promotional activities to improve private-sector awareness of NASA and other federal technology resources and opportunities.

NTTC History

NTTC is the hub of a national network linking U.S. companies with federal laboratories to turn federally-sponsored research into practical, commercially-relevant technologies and products. Located at Wheeling Jesuit University, NTTC has been part of the NASA-sponsored National Technology Transfer Network since 1991.

NTTC's National Gateway has facilitated more than 13,500 technical requests



since it opened in October 1992. Technology transfer professionals in 42 states have received more than 28,500 hours of training at NTTC workshops.

The NTTC also developed and produced the CD-ROM, *NASA Solutions: Sharing Aerospace Technology with America*, in collaboration with the NASA Commercial Technology Team.



Circle No. 845 On Fax Form



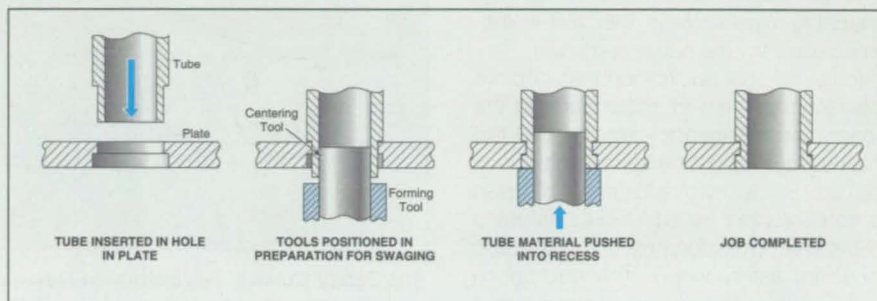
Swaging a Tube Perpendicularly to a Plate

No additional parts are needed.

Marshall Space Flight Center, Alabama

An inexpensive swaging technique has been devised for attaching a tube perpendicularly to a plate, without any additional parts. In the original application for which the technique was devised, the plate was a face plate for a coaxial fuel injector in a rocket engine, and the tube was the fuel sleeve (the outer coaxial member). The technique might prove cost-effective in many manufacturing situations in which there is need for rapid, inexpensive attachment of posts or tubes to base plates.

The technique (see figure) requires preparation by machining a stepped-diameter hole in the plate to receive the tube, and machining a reduced-diameter outer surface on a short length at the end of the tube to be inserted. This end of the tube is inserted in the hole from



The **Tube Is Quickly Swaged** to the plate, using simple tools.

the smaller-diameter side and temporarily restrained to prevent it from backing out under the force of subsequent swaging. Then a forming tool — basically a machined, hardened tube — is pushed hard toward the plate to swage the tube-end material into the larger-

diameter portion of the hole in the plate.

This work was done by Steven C. Fisher of Rockwell International Corp. for Marshall Space Flight Center. For further information, write in 47 on the TSP Request Card. MFS-31112

Compliant-Contact Ultrasonic Device for Inspecting Welds

Mounted in place of a welding torch, the device is operated at intervals along the torch trajectory.

Marshall Space Flight Center, Alabama

An improved device for ultrasonic inspection of welds made by a robot is designed to provide measurements of greater consistency than was previously achievable. With the workpiece still mounted in the welding station, the device is mounted on the welding robot in place of the welding-torch gas cup. The welding robot is then made to move along the same trajectory that it followed during welding. At desired small intervals along the trajectory, the device is pressed into contact with the weld to take the ultrasonic measurements.

The design of the device provides for compliant contact to accommodate misalignments and to ensure adequate coupling of ultrasound between the ultrasonic transducer and the workpiece, even when the surface of the workpiece is curved and/or irregular. Older ultrasonic inspection devices designed for the same purpose do not provide the necessary compliance, the defect signals that they generate are not consistent, and the coupling shoes of the ultrasonic trans-

ducers in those devices tend to hang up and thus fail to return to home position.

The present device (see figure) includes a generally cylindrical upper body that is screwed onto the welding-torch body (after the gas cup has been removed) by use of a one-turn-thread locking mechanism actuated by a knurled nut. Next, the bottom part of the device can then be rotated about the cylindrical axis to align the transducer shoe for proper contact with the workpiece, then locked. A circular rubber coupling provides the freedom for this rotation, plus compliance to accommodate tilting of the transducer axis from the nominal cylindrical axis.

The transducer shoe is mounted at the lower end of a pneumatic plunger, which is pressurized as needed to press the transducer against the workpiece. The pneumatic plunger features a slot-and-pin arrangement that limits rotation but allows linear displacement along the cylindrical axis of the transducer.

This work was done by Jeffrey L. Gilbert, William S. Hoult, Lisa M. Gelineau,

and Gareth L. Simpson of Rockwell International Corp. for Marshall Space Flight Center. For further information, write in 74 on the TSP Request Card. MFS-30092



A **Pneumatic Plunger** presses the transducer shoe against the workpiece with a force regulated via the applied pressure, while a compliant mount accommodates misalignments and irregularities.

Safety Cables as Substitutes for Lock Wires

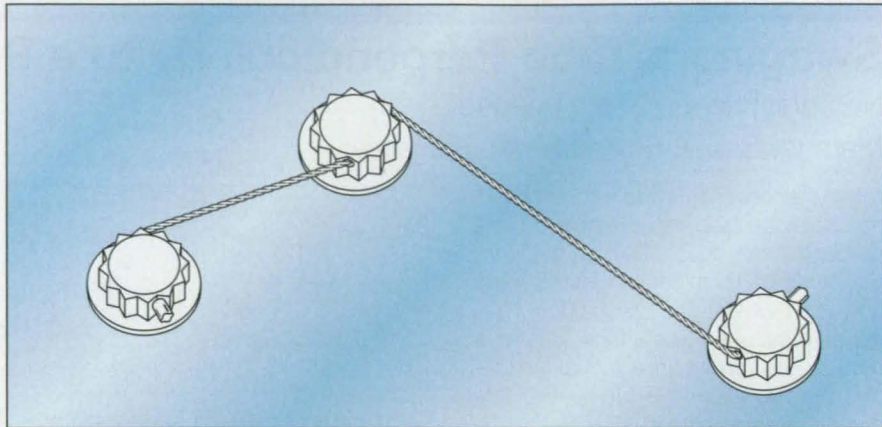
With the help of special tools, the cables can be installed more quickly and easily.

Marshall Space Flight Center, Alabama

Commercially available safety cables have been proposed as substitutes for the lock wires (safety wires) that are used to prevent loosening of nuts and bolts at critical locations in aircraft engines and other assemblies. These cables might also be useful as substitutes for the bendable washer tabs that are sometimes used for the same purpose.

In the original application that inspired this concept, two or more parts in the space shuttle main engine are secured together with safety wire in such a way that any tendency of a fastener to loosen is counteracted by additional tightening of the wire. Unfortunately, the procedure for using safety wire in this application requires at least 16 hours of training and is cumbersome in that it involves twisting a single wire in a prescribed pattern while keeping the wire in proper tension. Removal of the safety wire requires several cuts of the wire, thus creating foreign-object damage.

The commercial safety cables are 3 × 7 stranded cables of 0.032-in. (0.8-mm) diameter and are supplied in lengths of 12, 18, 21, and 24 in. (30, 46, 53, and 61 cm, respectively). A swaged fitting is installed on one end of each cable at the factory.



The **Safety Cable** in this installation prevents loosening of three fasteners.

In a given installation (see figure), a cable is strung through the fasteners in a direction which will provide positive pull on the fastener should it rotate. A ferrule is then installed on the free end of the cable by use of a special tool that tensions the cable, crimps the ferrule, and cuts off the remaining free length of cable — all in one stroke. To make it possible to remove the cable, all one need do is cut the cable at any single point along its length.

In comparison with the use of lock wires, the use of the commercial safety cables reduces installation time by more than half and rework time by more than 70 percent. It also requires only ten minutes of training.

This work was done by Jeff L. Beck and Danny G. Syto of Rockwell International Corp. for Marshall Space Flight Center. No further documentation is available. MFS-30070

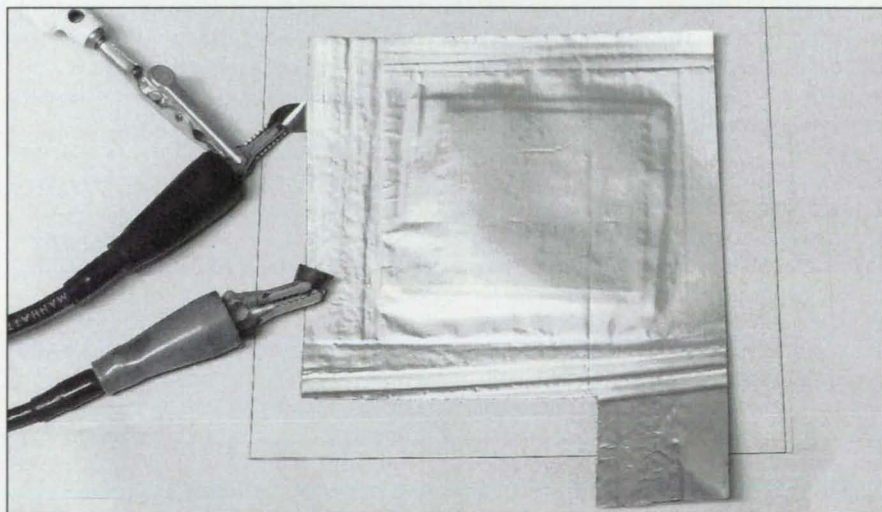
Improved Sealing of Li/Polymeric-Electrolyte/TiS₂ Cells

A cheap thermoplastic polymer prevents leakage between terminal tabs and cell envelopes.

NASA's Jet Propulsion Laboratory, Pasadena, California

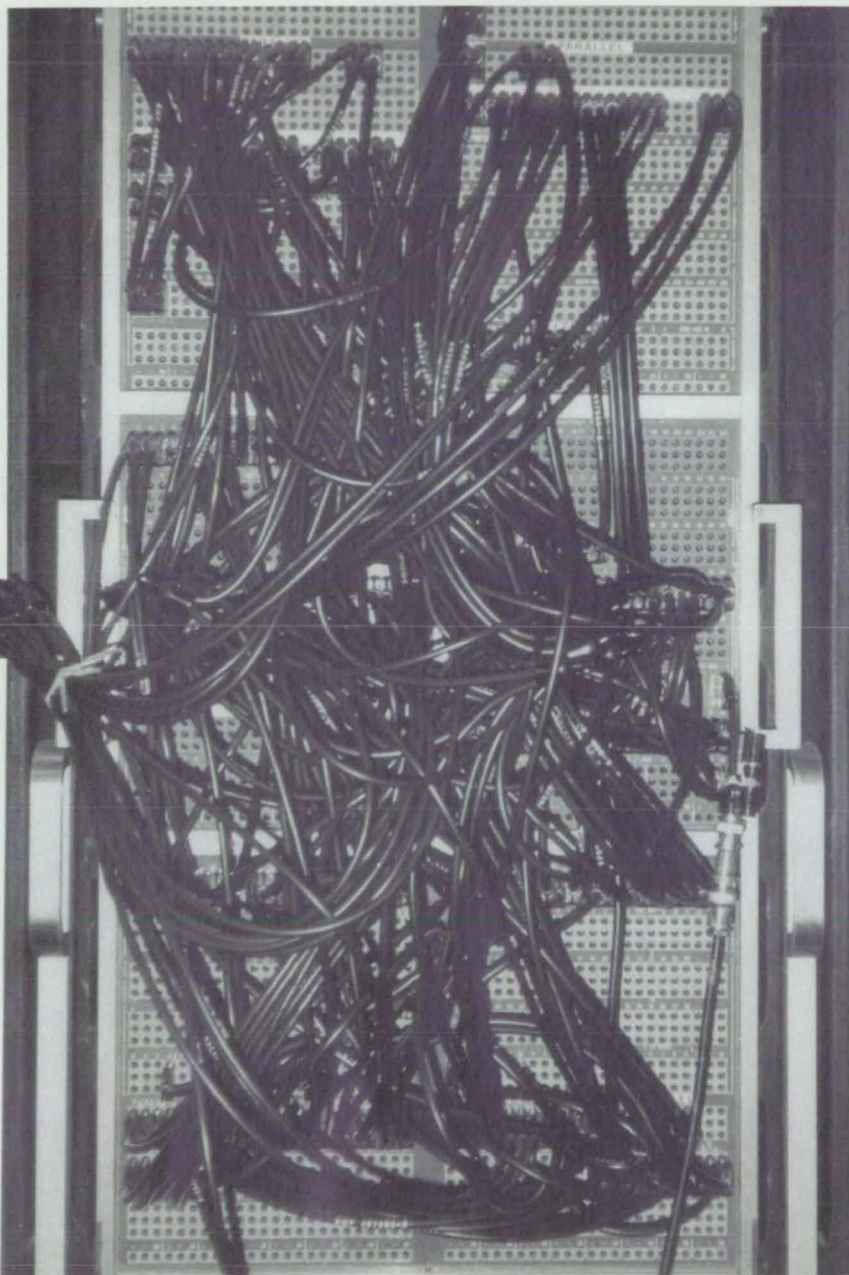
An improved method of sealing has been devised for use in the fabrication of lightweight Li-anode/polymeric-electrolyte/TiS₂-cathode electrochemical cells. These are rechargeable cells being developed for use in spacecraft, military, communications, automotive, and other applications in which high power and energy density are needed.

The figure shows an experimental cell of this type. Fabrication of such a cell involves (1) sandwiching the anode, cathode, and electrolyte materials between stainless-steel current-collector foils with terminal tabs, (2) inserting the sandwich through the open edge of a rectangular envelope that has been heat-sealed on three of its four edges and that is made of an aluminum foil laminated between layers of polyethylene, (3) heat-sealing to close the open edge of the envelope, including heat-



This **Experimental Li/Polymeric-Electrolyte/TiS₂ Cell** is a prototype of a class of lightweight, high-energy-density rechargeable cells. The cell envelope is about 4 in. (about 10 cm) square and about 0.032 in. (about 0.8 mm) thick. Its theoretical capacity and open-circuit potential are about 60 mA·h and 2.7 V, respectively.

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sealing the terminal tabs to that edge where they pass through from the inside to the outside, and (4) final heat-sealing of an evacuation port while drawing a vacuum through that port. Previously, leaks developed in the seals around the terminal tabs, because of lack of bonding between the terminal tabs and the polyethylene laminates.

The improved method of sealing is

similar to a previous method except that before assembling the cell, a commercial waxy thermoplastic polymer (Kodak A-1675 or equivalent) is dissolved in cyclohexane, the solution is applied to the terminal tabs, and the cyclohexane is allowed to evaporate. The resulting thin polymeric coats adhere strongly to the terminal tabs. These coats also adhere to the polyethylene envelope material

during subsequent heat-sealing, so that vacuum-tight seals are formed.

This work was done by Evan Davies, David H. Shen, and Ganesan Nagasubramanian of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 49 on the TSP Request Card. NPO-19216

Making Ion-Accelerator Grids From Carbon-Fiber-Tape Preforms

Flatter and stiffer grids are sought.

NASA's Jet Propulsion Laboratory, Pasadena, California

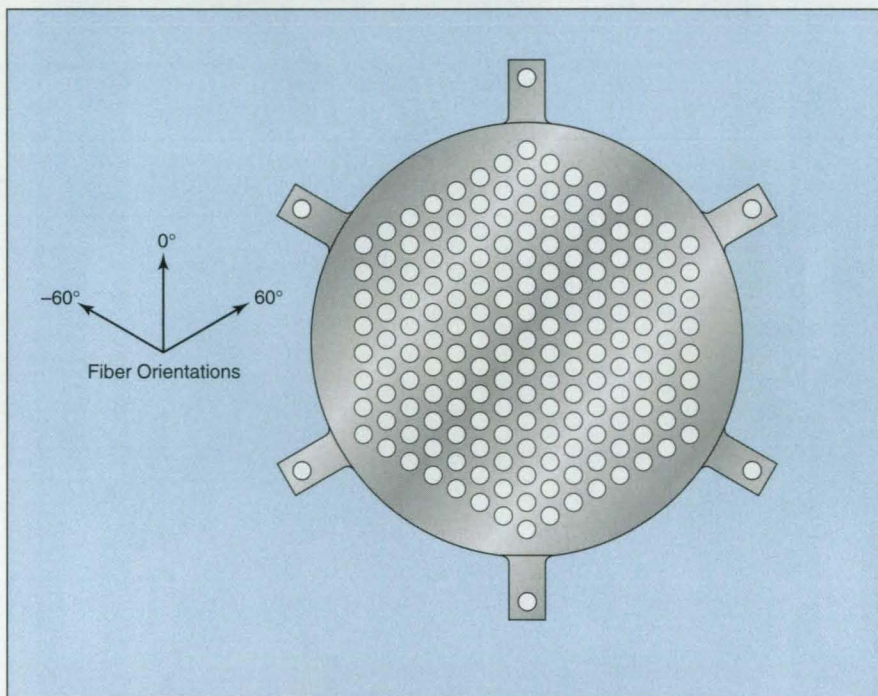
Ion-accelerator grids have been fabricated from carbon/carbon composite material by using unidirectional-carbon-fiber tape as the starting material. The reason for using the tape (instead of the woven carbon-fiber cloth that was used previously) is that the tape offers the potential for making smoother, flatter grids. Carbon/carbon grids are being developed as alternatives to molybdenum grids, which have been found to wear out quickly and to become so distorted by differential thermal expansion during operation that operating efficiency is degraded.

Early tests have shown that carbon/carbon composite grids last about ten times as long in operation as molybdenum grids do. Moreover, because of the low and even negative thermal expansion of carbon/carbon composite grids, thermal distortion is no longer large enough to cause appreciable loss of efficiency. However, carbon/carbon grids made from woven carbon-fiber cloth (the conventional preform material) have been found not to exhibit the flatness and stiffness needed to maintain the precision required for ion optics.

Unidirectional-carbon-fiber tape offers several advantages over woven carbon-fiber cloth: it provides greater flexibility in orientation of fibers, is thin enough that it can be stacked in multiple thin plies to fabricate thin parts with properly balanced layups, and is amenable to formation of a much smoother surface than is achievable with woven preforms. The use of unidirectional-carbon-fiber tape as the preform material was introduced in the fabrication of prototype carbon/carbon composite grids that were required to have thickness of 0.016 in. (0.41 mm) and flatness within ± 0.001 in.

(± 0.025 mm). The prototype grids were also required to exhibit maximum flexural stiffness along rows of holes in a hexagonal pattern.

The fabrication process devised to satisfy these requirements began with balanced layup of the unidirectional-fiber tapes, with fibers in successive layers oriented in a sequence of $[0^\circ, 60^\circ, -60^\circ]$ so that the fibers in each layer were parallel to one of the rows of holes (see figure). Following layup, the carbon blanks were held in fixtures that allowed gases to pass through. The fix-



An **Ion-Accelerator Grid** can be made from carbon/carbon composite material. Fabrication begins with stacking of unidirectional-carbon-fiber tape in layers with orientations in a sequence of $[0^\circ, 60^\circ, -60^\circ]$ to match the orientations of rows of holes to be machined later.

tured blanks were subjected to cycles of chemical-vapor infiltration and heat treatment to a temperature of $3,000^\circ\text{C}$ to obtain carbon/carbon composite material of maximum stiffness. There was also a long heat treatment at $2,200^\circ\text{C}$ to relieve stresses in the blanks while they were held flat.

This work was done by D. Kyle Brown, Charles E. Garner, and Juergen Mueller of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 93 on the TSP Request Card. NPO-19540

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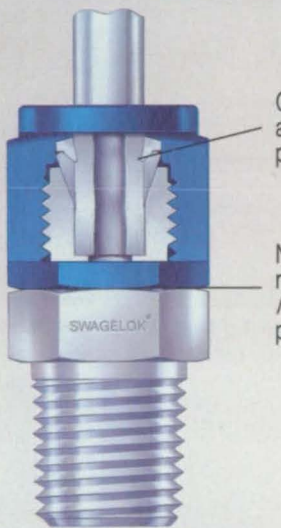
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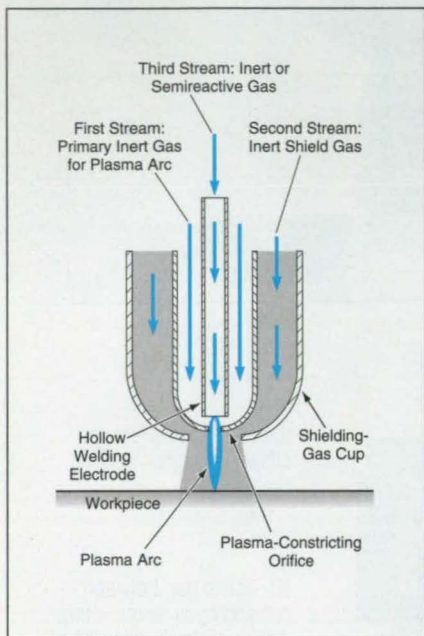
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Ternary-Gas Plasma Arc Welding

Shielding and plasma gases are joined by a third, stabilizing flow.

Marshall Space Flight Center, Alabama

Ternary-gas plasma arc welding, as its name suggests, is a plasma-arc-welding process in which three streams of gas are directed toward the workpiece through various orifices in the welding torch (see figure). The ternary-gas concept is applicable to both direct-current straight polarity and variable-polarity welding modes, both with and without keyhole penetration.



A Third Gas Flows Through the Hollow Welding Electrode, helping to produce a stiffer, narrower welding arc.

The first stream consists of an inert gas that flows over the welding electrode and is used to create the welding arc. The second stream consists of an inert gas that flows through a cup that surrounds the welding electrode. This stream constricts the welding arc to a narrow column, provides some control over weld penetration, and augments the shielding effect of the first stream, helping to surround the hot weld zone with an inert atmosphere to prevent oxidation and contamination. The third stream consists of a gas that flows through the welding electrode (which is made hollow for this purpose) into the plasma zone.

The innovative feature of this process lies in the incorporation of the third stream. This stream acts in conjunction with the second stream in helping to maintain a straighter, narrower, more stable arc. In effect, it helps to stiffen the arc, making it less subject to skewing and to distortion of its symmetrical shape. In doing these things, the third stream should increase weld penetration at any given current setting. The third gas can be a single gas or a mixture and can be inert or semireactive, depending on the application.

In comparison with other plasma arc welding processes, the ternary-gas plasma-arc-welding process is expected to be less dependent on the technician's skill and to be capable of joining

thicker materials with relatively low heat inputs. It is also expected to yield more desirable and consistent mechanical and physical properties, including fewer defects and greater ultimate tensile strength. It is expected to be more economical and efficient because of the reduced incidence of defects and because welding can be done faster.

Ternary-gas plasma arc welding is expected to be particularly suitable for workpieces made of aluminum alloys and for which preserving as much as possible of the strength of the base material is a major concern. Ordinarily, aluminum base material retains only 50 to 65 percent of its strength after welding. With the narrower weld bead and heat-affected zone and controlled penetration of the three-gas process, the postwelding ultimate strength of the base material is expected to be a greater fraction of its prewelding value.

This work was done by Daniel J. Rybicki and William F. McGee of Martin Marietta for **Marshall Space Flight Center**. For further information, **write in 20** on the TSP Request Card.

This invention has been patented by NASA (U.S. Patent No. 5,399,831). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28857.

Process for Making Small Quantities of Refractory Tiles

John F. Kennedy Space Center, Florida

A process for making small quantities of fibrous refractory ceramic tiles at Kennedy Space Center has been developed by modifying a larger-scale laboratory tile-production process established at Ames Research Center. The process is designed expressly to produce tiles economically for use in maintenance of the outer layer of thermal insulation on the space shuttle. The process can also be used to make blocks of commercial-grade refractory materials with properties tailored to specific applications; e.g., for use in calcining trays, kiln furniture,

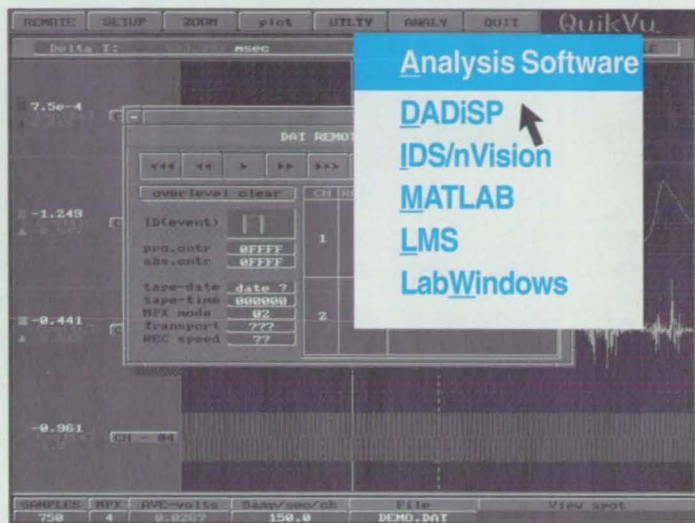
kiln hearths, and machine setters. The raw materials used to make the refractory tiles are silica and aluminoborosilicate fibers, silicon carbide, ammonium hydroxide, and water. The major steps in the process are (1) blending lots of raw materials to obtain consistent properties, (2) chopping and compressing fibers into blocks of consistent dry density and fiber orientation, (3) consolidation of blocks by sintering at high temperature, (4) trimming to final dimensions, and (5) testing to ensure compliance with specifications.

This work was done by Bruce V. Lockley of **Kennedy Space Center** and Jeffrey A. Andress, Stamatios Hadoulas, Gerald K. Marshall, Daniel E. Rhyne, Clarence D. West, Daniel J. Whitacre, and Martin J. Wilson of Rockwell International Corp. For further information, **write in 67** on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11839.

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For More Information Write In No. 662

Ultrasonic Impact Grinding for Making Ion-Accelerator Grids

High-quality holes are formed in carbon/carbon sheets.

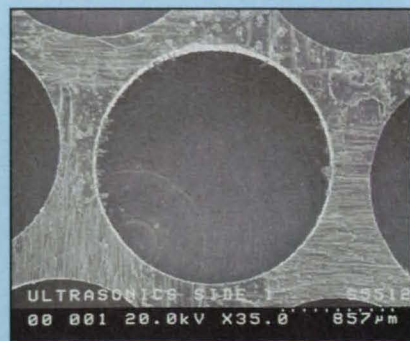
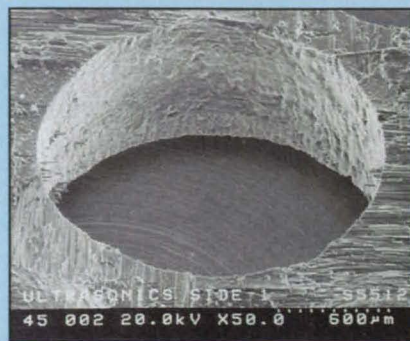
NASA's Jet Propulsion Laboratory, Pasadena, California

Ultrasonic impact grinding has been found to be a suitable technique for machining holes in carbon/carbon sheets to make grids for ion accelerators. The holes made by ultrasonic grinding have smooth, straight walls with well-defined, sharp edges (see figure).

Heretofore, ion-accelerator grids have been made of metal. The use of carbon/carbon grids is a subject of continuing research in an effort to increase the lifetimes and improve the performances of future ion accelerators. Fabrication of such a grid typically involves drilling several thousand closely spaced holes between 1 and 2 mm in diameter.

Because carbon/carbon is relatively chemically inert, etching is not a suitable technique for making the holes. Conventional mechanical drilling may lead to breaking away of the webbing material between the holes, in particular for open-area fractions of 70 percent or higher. This is caused by fibers getting caught in the drill and being pulled out of the surrounding matrix material. Laser drilling can be used, but it yields holes with craterlike shapes. Worse yet, water-jet blasting causes large chunks of material to break away, yielding holes of poor quality.

In ultrasonic impact grinding, an abrasive slurry is introduced into the region of contact between a cutting tool and a workpiece, and vibrations with amplitudes of the order of hundredths of a millimeter and frequency of the order of 20 kHz are induced in the tool by use of



HOLES MADE BY ULTRASONIC IMPACT GRINDING



HOLE MADE BY LASER DRILLING



HOLE MADE BY WATER-JET BLASTING

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a piezoelectric or electromagnetic transducer excited by a signal at that frequency. The vibrations are transmitted from the tool to the abrasive particles, causing the particles to grind a hole in the workpiece. The outline of the hole makes a close match with the outline of the cutting tool.

This work was done by Charles E. Garner and Juergen Mueller of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 97 on the TSP Request Card. NPO-19245

Indium Bonding Without Flux

Ductile flow of indium suffices to remove surface oxide.

Lewis Research Center, Cleveland, Ohio

Two workpieces made of similar or dissimilar metals or other materials can be joined by a solderlike bond or seal, using indium as the interfacial material. The art of indium bonding is not new; what is new is a relatively-low-temperature indium-bonding technique in which there is no need for acid-paste indium-soldering flux. The advantage of fluxless indium bonding is that the resulting joint is clean: heretofore, it has been necessary to clean off flux after indium soldering by use of 1,1,1-trichloroethane, which must be

phased out by law because it contributes to depletion of ozone from the Earth's upper atmosphere.

The fluxless indium-bonding technique is based partly on the observation that pure indium is very soft, and when it flows under applied pressure, shear forces break up the surface oxide, exposing fresh indium. The freshly extruded indium forms bonds with the oxides at the surfaces of the parts to be joined.

In preparation for indium bonding by this technique, the parts to be joined are

cleaned. Then a clean wire, ribbon, or preform of the required size and shape is placed in the specified bonding position between the parts. The parts are pressed together, squeezing the indium down to the desired thickness (see figure).

A variation of the technique exploits the tendency of indium to enter into alloys with gold, nickel, and palladium at relatively low temperatures. One or more of these alloying elements can be plated onto the objects to be joined. Alternatively, the alloying elements can be

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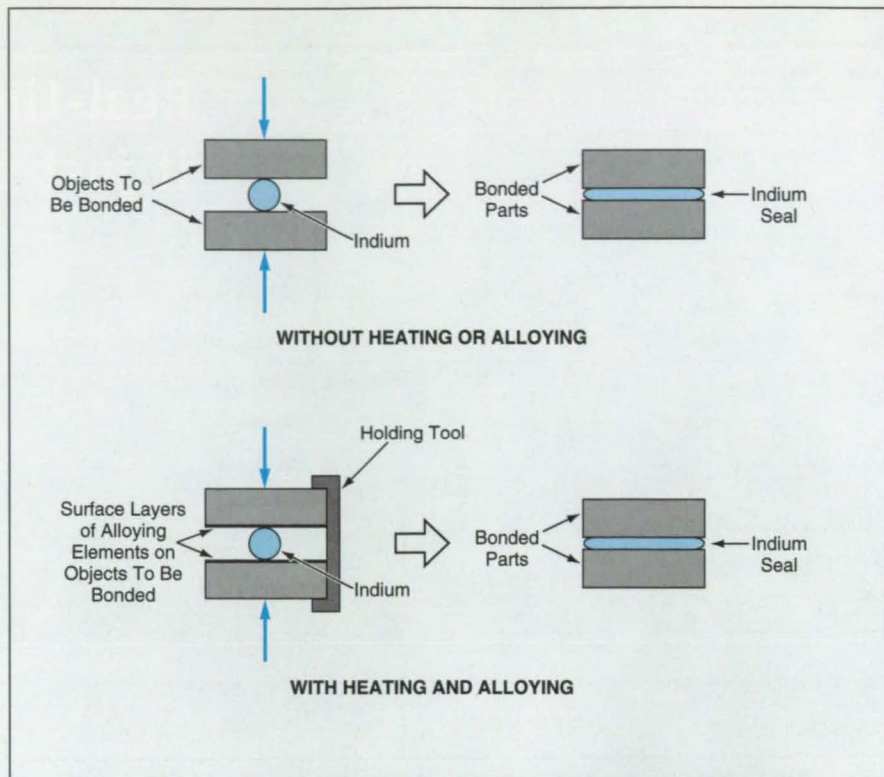
applied by painting the bonding surfaces of the objects with organometallic inks, then heating the objects in a furnace to decompose the organic constituents and deposit the alloying metals.

Once the bonding surfaces of the objects are coated with the alloying metal(s), a piece of indium is placed between the objects as before, and the objects are put in a holder, which is placed in a heating fixture in a vacuum. The clamped objects are then heated in the vacuum until the indium completely wets the bonding surfaces on the objects to be joined.

The fluxless indium-bonding technique has been used in manufacturing a ring-laser gyroscope. With gold as the alloying element, aluminum/copper electrodes were indium-bonded to a ring-laser frame made of a low-thermal-expansion glass ceramic.

This work was done by Benjamina G. Montoya of Rockwell International Corp. for Lewis Research Center. For further information, write in 69 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-15785/86.



Fluxless Indium Bonding can be done without heating or with heating in a vacuum, depending on whether alloying coating layers are used.

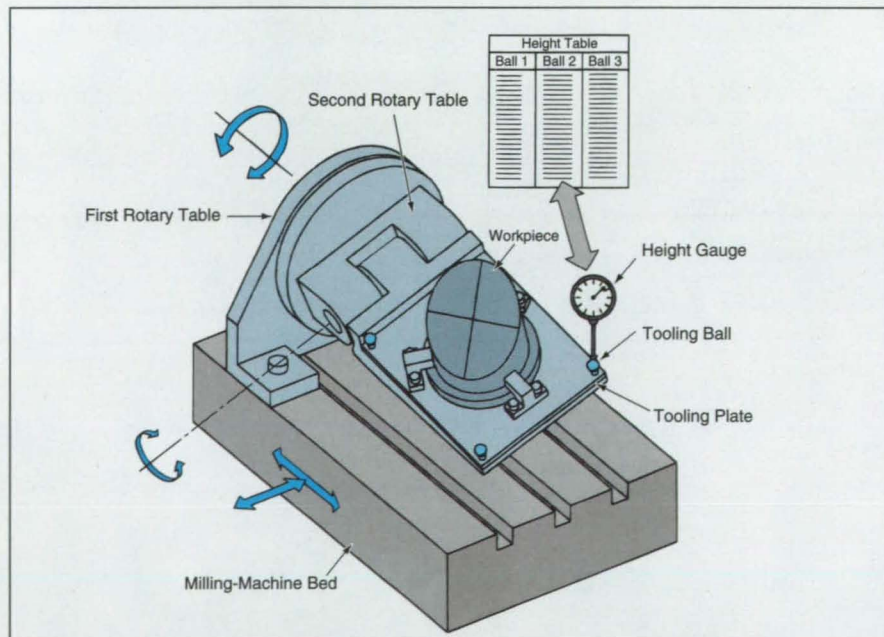
Technique Increases Precision in Machining a Compound Angle

Angles are set in terms of Cartesian coordinates of tooling balls.

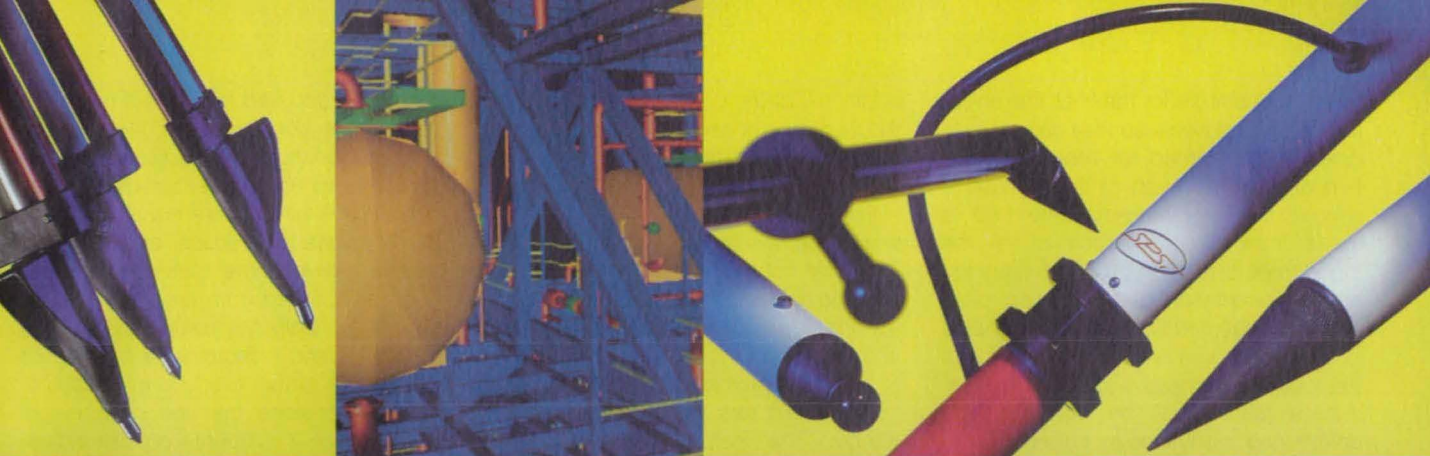
NASA's Jet Propulsion Laboratory, Pasadena, California

A technique for setting up a workpiece to be milled at a compound angle is capable of angular precision on the order of a few arc seconds. This degree of precision is equal to or greater than that achievable by two other familiar techniques, one of which involves the use of a dual sine plate, and the other of which involves the use of a sine plate on a rotary table. In addition, this technique easily allows for multiple setups on a single workpiece.

In this technique, a first rotary table is mounted on the bed of a milling machine, and a second rotary table is mounted on the first rotary table with its axis of rotation nominally orthogonal to that of the first rotary table. A tooling plate with tooling balls is mounted on the second rotary table, and the workpiece is mounted on the tooling plate (see figure). The rotary tables are used as convenient means for adjusting the orientation of the workpiece to the desired compound angle, but the angle indicators on the rotary tables are not

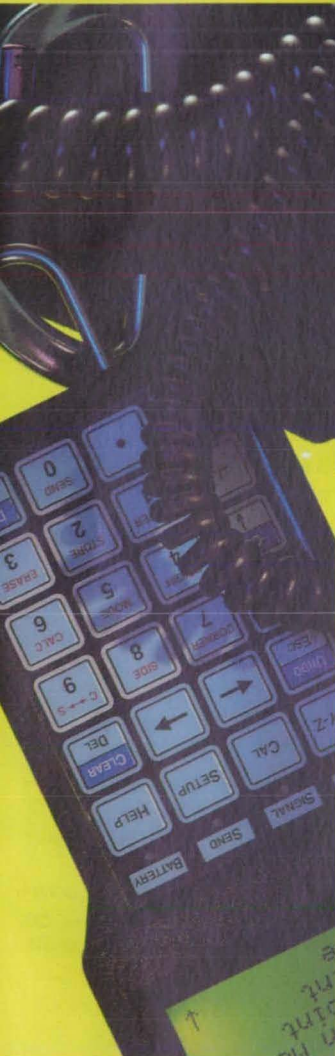


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used as indicators for the final, fine angular adjustment because they are not precise enough. Instead, the final determination of the orientation of the workpiece relative to the milling-machine bed is made from a combination of (a) the trigonometric relationships between the angular orientation of the tooling plate and the measured Cartesian coordinates of the tooling balls and (b) the locations of the tooling balls relative to the mounting-surface features of the workpiece, as determined in advance by inspection and precise measurement.

In principle, at least three tooling balls are needed to establish the orientation of the tooling plate and workpiece. If desired, more can be used, in which case the redundant information from the

additional ball(s) can be used to confirm the accuracy or reveal any errors, as the case may be, in the record of measurements on the other balls.

For any given desired orientation of the workpiece, the tooling balls have unique Cartesian coordinates relative to a specified origin. Typically, the origin lies on the surface of the milling-machine bed; the x and y axes are nominally horizontal and lie along and across the bed, respectively; and the z axis projects upward from the bed. The coordinates of the balls for each desired orientation of the workpiece can be obtained most conveniently by using a computer-aided-design program to implement the geometric relationships mentioned above in (a) and (b). In setting up the workpiece for milling, the rotary

tables are adjusted, one at a time, to set each at its component of the required compound angle. The adjustments are complete when the measured Cartesian coordinates of the balls equal the computed values. In practice, once the distances between the tooling balls have been established from the initial inspection, it is usually not necessary to measure the x and y coordinates of the balls during the setup procedure; measurement of z alone (by use of a height gauge) gives a sufficiently precise indication of the compound angle.

This work was done by Richard E. Fleischner of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 99 on the TSP Request Card. NPO-19756

Improved Weld-Filler-Wire Guide Tip

A V-groove would keep wires of various diameters centered over weld seams.

Marshall Space Flight Center, Alabama

A proposed improved weld-filler-wire guide tip would feature a guide hole with V-groove sides instead of the customary circular-hole cross section with small diametral clearance (see figure). The V-groove guide tip would overcome two small but persistent disadvantages of customary guide tips; (1) the need to install a different guide tip when changing to a wire of different diameter and (2) the tendency of the wire to shift laterally within the diametral clearance, especially where the wire is bent or it is subjected to a lateral force, making it difficult or impossible to center the wire on the weld seam.

The V-groove tip would accommodate wires of different sizes and would maintain the lateral position of the wire consistently, so that less cross-seam adjustment would be necessary and more precise positioning of the wire would be

attainable. The angle of the V-groove would be chosen to prevent binding in the event that the wire expands or the guide contracts. The force on the wire from contact with the workpiece, or from a spring, roller wheel, or other device would keep the wire pressed against the sides of the V-groove, so that in the event of variations in the size of the wire on account of manufacturing tolerance or thermal expansion, the wire would simply move up or down the sides of the groove, the axis of the wire remaining on the midplane of the V-groove at all times.

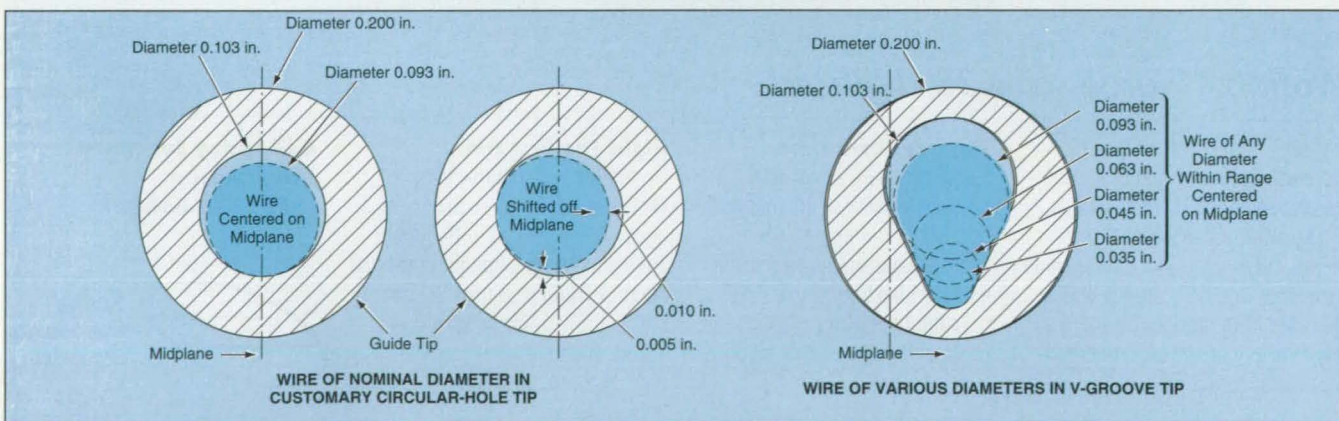
The sides of the V-groove would make contact with the wire along two lines instead of along only one line in a circular-hole tip. This doubling of the contact surface should provide better electrical connection — an advantage for "hot"-wire feeding and electrical wire-contact-and-

dripping sensors. The doubling of contact surface should also reduce the rate of wear because the contact loads would be less concentrated.

The only disadvantage of the proposed guide tip is that it would be more difficult to fabricate because unlike a circular hole, the V-groove hole could not be made by simple drilling. The V-groove would likely have to be made by electrical-discharge machining or broaching.

This work was done by Stephen S. Gordon of Nichols Research Corp. for Marshall Space Flight Center. No further documentation is available.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26343.



The **Proposed V-Groove Tip** would accommodate wires of various diameters, keeping them centered on the midplane of the V, whereas the wire can move off the midplane in a customary circular-hole tip. The dimensions shown here are for example only.

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Hollow Silicone-Rubber Mandrels for Curing Composite Tubes

Pressures no longer rise uncontrollably to excessive values.

Goddard Space Flight Center, Greenbelt, Maryland

Improved silicone-rubber mandrels have been devised to apply pressure to the inner surfaces of square-cross-section matrix/fiber composite tubes during the stage of fabrication in which the matrix material is heated to cure it. Previously, solid silicone-rubber mandrels were used for this purpose; because of the high rates of thermal expansion of silicone, it was difficult to regulate the pressures applied by the mandrels, and these pressures often rose uncontrollably to levels far in excess of those required.

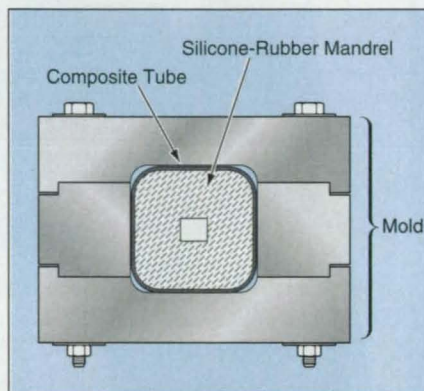
The improved silicone-rubber mandrels are made more compliant by making them hollow. Typically, this involves a square-cross-section axial hole (see figure). When a hollow mandrel expands during heating to the curing temperature, it expands at the same rate as that of the solid mandrel, but the pressure it exerts on the composite is lower because the outer mandrel material is no longer trapped between the composite tube and a solid core. Instead, the mandrel is free to yield by collapsing into the square hole. The hole is sized so that the silicone rubber completely fills the hole just as the curing temperature is reached.

The square-cross-section composite tubes in the original application are to be incorporated into optical benches and truss structures with gusseted joints. These tubes are 6 ft (183 cm) long, 1.75 in. (4.45 cm) square in cross section, and are made of epoxy matrix reinforced by graphite fibers, in a 16-ply nominal wall thickness of 0.080 in. (2.0 mm). Whereas the curing pressure ranged between 1,500 and 1,800 psi (10 to 12 MPa) with solid mandrels, it ranged from 50 to 150 psi (0.34 to 1.0 MPa) with hollow mandrels. The amount of resin lost during the cure was reduced from a typical value of 9 g with a solid mandrel to less than 1 g with a hollow mandrel.

Square holes were found to work better than round holes for making square tubes. Round holes tend to collapse into ovals, leaving pairs of opposite sides of the tubes either too thick or too thin, with variations in thickness of as much as 0.020 in. (0.5 mm) between adjacent sides. Square holes collapse more consistently and uniformly during the cure, leaving the sides only slightly thicker [by 0.003 to 0.005 in. (0.08 to 0.13 mm)] on their center lines. The only advantage of

solid mandrels over hollow ones is that the corresponding variations in thickness are slightly smaller, ranging from 0.001 to 0.002 in. (0.025 to 0.05 mm).

This work was done by James Parker, Peter Blake, Laurence Madison, and David Puckett of Goddard Space Flight Center. No further documentation is available.
GSC-13696



The Silicone-Rubber Mandrel Presses Outward against the composite tube in the mold used for curing. The hole in the mandrel allows the mandrel to collapse inward to relieve some of the pressure generated by thermal expansion of the mandrel against the tube and mold.

Baffles for Autoclave Curing of Graphite/Epoxy Tubes

Temperature gradients are reduced by using baffles to redirect the flow of heated nitrogen.

Goddard Space Flight Center, Greenbelt, Maryland

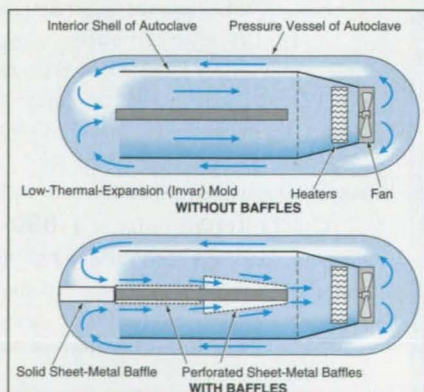
The figure illustrates the different flows of heated nitrogen in two versions of an autoclave used to cure a graphite-fiber/epoxy-matrix composite tube. The first version does not contain baffles. The second version contains metal baffles, which redirect and diffuse the flow along the length [6 ft (1.8 m)] of a mold that holds the composite tube.

In the absence of baffles, the hot flow is focused on the upwind (left) end of the mold, so that heating is more rapid in the upwind than in the downwind region of the mold and tube; the upwind end has been observed to be as much as 90 °F (50 °C) hotter than the downwind end

during initial heating. The large gradient of temperature can lead to distortion of the tube and/or different parts of the tube being at different stages of cure. In the presence of baffles, the redirected and diffused flow provides more nearly even heating along the mold and tube, reducing the end-to-end temperature difference to < 15 °F (< 8 °C).

This work was done by James Parker and David Puckett of Goddard Space Flight Center. For further information, write in 61 on the TSP Request Card.

GSC-13698



In the **Autoclave Without Baffles**, heated N₂ gas flows in a pattern that results in faster heating at the left end of the mold. In the autoclave with baffles, the flow of hot N₂ is directed more nearly evenly along the tube to even out the heating pattern.

Polishing Coated Turbine Blades

Polishing increases turbine efficiency.

Marshall Space Flight Center, Alabama

An abrasive-flow machining process has been developed to polish thermal-barrier surface layers that have been plasma-sprayed onto turbine blades, which can have complex shapes. The insulating thermal barrier coatings mitigate thermal shock to the components, thereby reducing the incidence of thermally induced low-cycle fatigue cracks and, consequently, prolonging blade life. The abrasive-flow machining process produces the smooth blade finish needed for maximum turbine efficiency and helps to preserve the lifetime-prolonging benefit of the coating layers by minimizing the amount of coating material removed in polishing.

In the original application for which the abrasive-flow machining process was developed, the thermal-barrier coating layers were applied by air plasma spraying to the blades of the high-pressure fuel turbo-pump in the main engine of the space shuttle. The coating layers as sprayed exhibited surface finishes of $> 500 \mu\text{in.}$ ($> 13 \mu\text{m}$) root-mean-square (rms) roughness. The abrasive-flow machining process was shown to be capable of polishing the entire airfoil surface of a blade (see figure) to a finish of 32 $\mu\text{in.}$ ($0.8 \mu\text{m}$) rms roughness.

The process involves the use of a slurry composed of a polymeric compound laden with abrasive aluminum oxide, boron carbide, diamond, or silicon carbide. The polymeric compound can be adjusted for different viscosities to tailor the process to the component being polished. Different abrasive sizes are used to produce optimum polishing for the surface material, and precise tooling is necessary for uniform polishing of the entire airfoil surface.

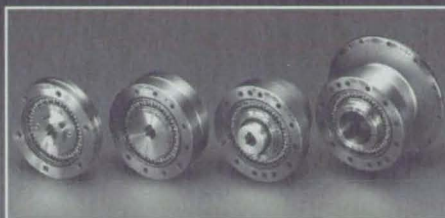
The benefits of the combination of plasma spraying and abrasive-flow machining

of the thermal-barrier coating layers include not only smooth surface finish but also uniform coating thickness around the airfoil cross section. The abrasive-flow machining process can be used to polish coating layers that have been applied by either air or vacuum plasma spraying and that comprise either metals or metal/ceramic composites. In the original application, the use of the polished coated blades increased the turbine efficiency at

the rated power level by 2.5 percent in comparison with the efficiency obtained with unpolished coated blades.

This work was done by Richard Holmes and Frank Zimmerman of Marshall Space Flight Center and Timothy N. McKechnie of Rockwell International Corp. For further information, write in 75 on the TSP Request Card.
MFS-30082

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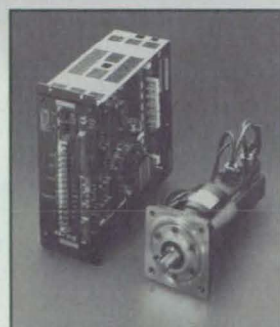
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Vacuum- and Air-Plasma-Sprayed Turbine Blades were polished by abrasive-flow machining. (Polishing was limited to airfoil surfaces, there being no need to polish the shank portions of the blades.)



Mathematics and Information Sciences

Quadratic-Programming Collision-Avoidance Algorithm

Redundant degrees of freedom are exploited to satisfy obstacle-avoidance and other constraints.

John F. Kennedy Space Center, Florida

A quadratic-programming algorithm has been devised for controlling a multiple-joint robot arm in such a way as to simultaneously (a) make the end effector (the robot hand at the tip of the arm) follow a specified trajectory, (b) make the rest of the arm avoid obstacles in response to the outputs of proximity sensors at various locations along the arm, and (c) satisfy other constraints and/or requirements, which include limiting joint angles, avoiding motion singularities, and limiting speeds to safe values. The algorithm exploits redundant degrees of freedom of the robot arm; for example, it can configure the arm to reach around an obstacle to put the end effector in a desired position and orientation.

The general quadratic-programming (QP) problem is to find values of a set of variables (e.g., joint angles and velocities) that minimize a quadratic cost function, subject to a set of linear equality and inequality constraints. Robot-arm-motion-control terms that can be implemented in the QP approach include joint-spring and motion-minimizing terms, and terms that express constraints and other requirements like those mentioned in the preceding paragraph. Priorities are assigned to the constraints and requirements. Each term can be treated either as a constraint (e.g., a requirement to follow a commanded trajectory precisely) or as a contribution to an optimization function (e.g., deviation from a commanded trajectory contributes to a quadratic cost function.)

The algorithm is executed repeatedly in time steps. At each step, a QP problem is formulated and solved for a set of incremental joint displacements, which are added to the joint positions computed previously to obtain new joint positions. The various motion-control terms can impose conflicting requirements. The conflicts are resolved partly by taking account of the priorities in the constraints; the constraints of higher priority get preference in the solution process.

Collision-avoidance terms are treated, variously, as contributions to the cost

function or as constraints at different times in the solution process. During approach to an obstacle, and while the arm is still at some distance from the obstacle, a repulsion term is first added to the quadratic cost function to tend to drive the approach point away from the obstacle. If the distance becomes too small, an inequality constraint of higher priority is added to stop the approach, maintaining a minimum specified distance. In both cases, the terms are formulated in joint space by use of the Jacobian that relates the motion of the approaching point (e.g., the location of a sensor) to the joint motions.

The present QP algorithm follows an approach similar to that of the simplex method for linear programming in that all equations are formulated in terms of a set of defining variables, and the solution process involves motion along constraint surfaces, with swapping of defining variables as different constraints are activated and rewriting of a derivative matrix at each step. Unlike in some other approaches, only a minimal set of coordinates is used; that is, there are no Lagrange or auxiliary variables. Priorities are defined for each constraint and determine which constraints take precedence when conflicts arise. The solution procedure satisfies as many constraints as possible, including optimality conditions, in order of decreasing priority. The algorithm efficiently handles all combinations of equality and inequality constraints, including those with degeneracies, overlaps, and conflicts.

The algorithm begins by initializing a table that contains a row for each of N free variables, a row for the derivative of the quadratic cost function with respect to each variable, and a row for each equality and inequality constraint. The table includes one column for each free variable, as well as a column of residual quantities. For each free variable and derivative term, the residual quantity is defined as the value of that free variable or derivative term. For each constraint term, the residual quantity is indicated by how much the constraint is violated (a negative value indicates that the con-

straint is not active). The free variables constitute the initial set of defining variables and their initial values are set to zero.

There follows a solution procedure that consists of the following steps:

1. Find the currently violated constraints of highest priority.
2. Find which, if any, defining variable can be changed to satisfy the constraint.
3. Compute the maximum change in the selected defining variable before a constraint of the given or higher priority is reached.
4. Adjust the column of residual quantities to reflect this change in the value of the defining variable.
5. Change the defining variable to be the constraint that is reached, and update the matrix of derivatives to reflect the new set of variables.
6. Change the rows corresponding to the derivatives of the cost function to provide the derivatives in terms of the new set of variables.

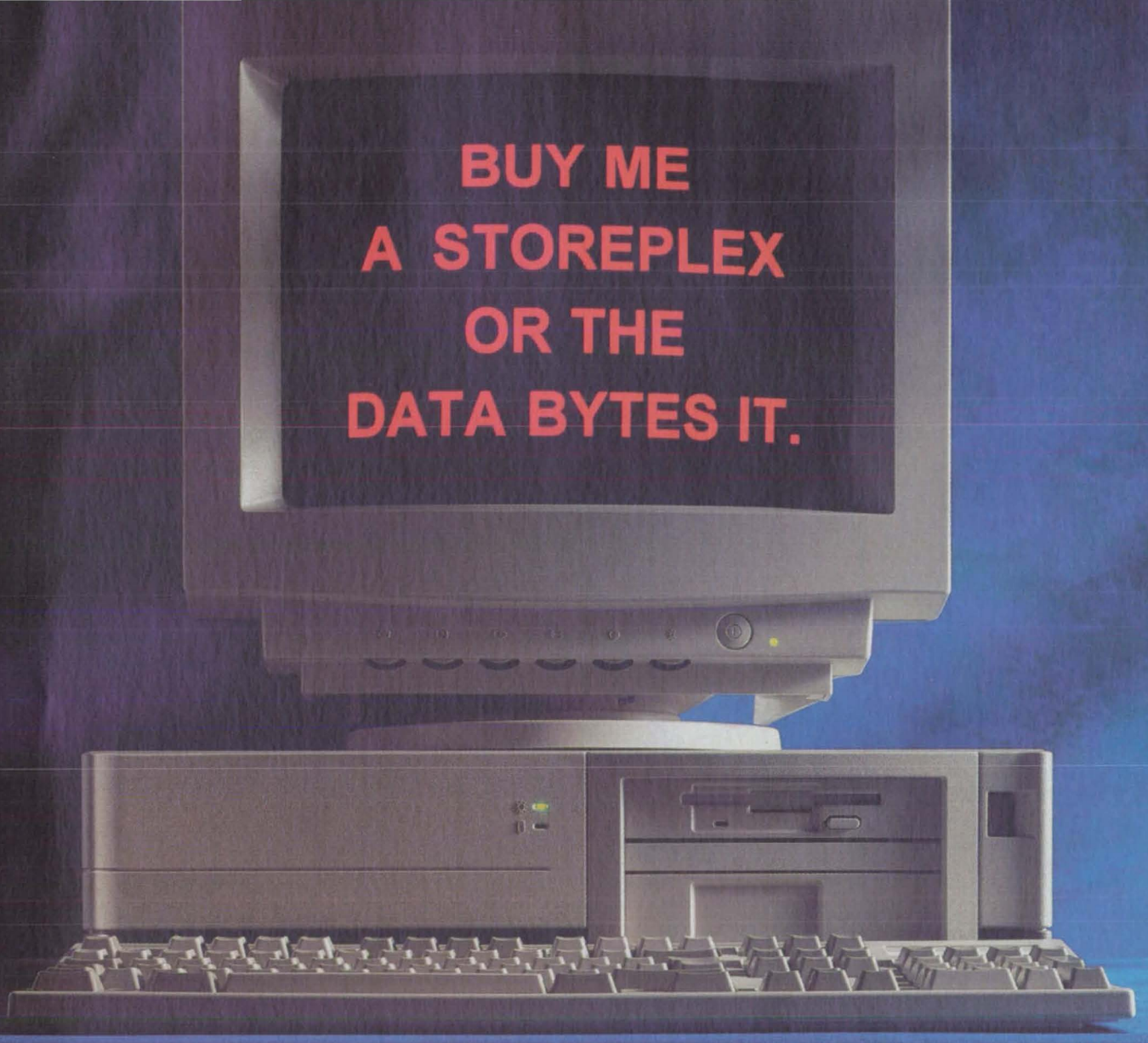
These steps are reiterated until all constraints that can be satisfied are satisfied and there is no further room for optimization. The optimal values for the variables are given as the residual values in the first N rows of the final table. The residual values in the next N rows contain the derivatives of the quadratic cost function with respect to the final set of defining variables.

This work was done by Mark M. Thomas of Merritt Systems, Inc., for Kennedy Space Center. For further information, write in 22 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

*Tom Pigoski
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For More Information Write In No. 632

Program for Simulation and Control of a Robotic Manipulator

A common graphical user interface facilitates simulation or control in several operating modes.

John F. Kennedy Space Center, Florida

The Robotic Simulation and Development Environment (RSIM) computer program provides a comprehensive set of capabilities for simulating and controlling a kinematically redundant, multiple-serial-link robot arm. RSIM can be used, for example, to investigate layouts of robot work cells and kinematic designs of robot arms, to test robot-arm trajectories and trajectory-planning algorithms, and to train robot operators. RSIM is written in C++ and can be executed on a personal computer under a Windows operating system. The C++ implementation makes the software extendible, enabling users to readily incorporate custom software.

RSIM provides for kinematic simulation of robot arms, multiple animated views of robot work cells, and real-time control of real robot arms that can be equipped with proximity sensors along their entire lengths ("whole-arm sensing systems"). RSIM features a common graphical user interface for simulation or for control of a real robot. RSIM accommodates several robot operating modes, including modes characterized by joint-interpolated motions; modes that involve straight-line Cartesian motions; active collision-avoidance modes; and teleoperator, repeller, and autonomous modes.

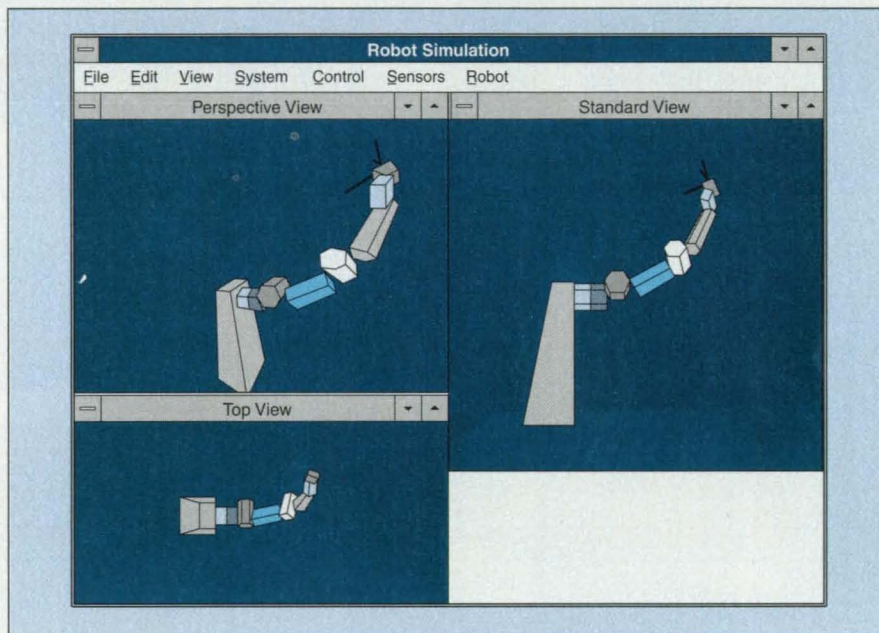
The figure presents an example of a graphical user interface for a typical application. The command menus of the graphical user interface include standard "file" and "edit" menus; selections for creating and handling animated views; and commands that execute the simulation, control the robot system and operate arrays of proximity sensors. Each animation window presents a picture of the robot and its environment from the perspective of a window or camera. Objects are depicted in simplified forms as solid-surface or wire-frame polyhedral models generated by use of efficient coordinate transformations. Hidden surfaces are removed from pictures of solid models. The display is free of flicker.

The parts of RSIM devoted to control and simulation enable kinematic and graphical modeling of general robotic manipulator arms with multiple rigid links in series with revolute joints, and can readily be extended to include joints of other types. RSIM can, in principle, accommodate multiple robots on moving bases (including robotic vehicles), but does not, at present, include means for

specifying the motions of the bases. Descriptions of robot geometry, graphical representation, control parameters, and other data are stored in ASCII text files for generality and ease of use. For efficiency, a standard recursive approach is taken in computing forward kinematics. The graphical structure and objects of interest in each link in a robot arm are defined in terms of a reference frame fixed in the link

signal level is set for the sensor.

The robot-control part of RSIM incorporates an iterative collision-avoidance trajectory-generating algorithm described in the preceding article, "Quadratic-Programming Collision-Avoidance Algorithm" (KSC-11807). The robot-control part of the software also interacts with the robot control equipment, getting information on the status of the robot



The **Graphical User Interface** of RSIM has a standard personal computer/Windows appearance and menu structure that, together, promote familiarity and ease of use.

and can readily be converted to world coordinates by use of a specification of the position and orientation of the link. The graphical representation of a link consists of a set of vertex points connected by line segments to form a wire-frame or solid-surface polyhedral model. Objects of interest in each link can include points and frames to which objects (e.g., cameras) are attached.

RSIM can, if desired, be used to simulate the operation of arrays of proximity sensors. In such a simulation, the distances of closest approach between each sensor and any objects in the environment are computed: A bounding-box test is first done to prune the number of objects to be checked, and an efficient search algorithm computes the closest-approach vectors. If any distance of closest approach is less than the range of the corresponding sensor, a corresponding

and updating joint commands at the real-time data rate of the robot control loop. The software also operates the array of proximity sensors.

This work was done by Mark M. Thomas of Merritt Systems, Inc., for Kennedy Space Center. For further information, write in 72 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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TANPO Map

Data for computerized rendering of stereoscopic views are organized for efficient access.

NASA's Jet Propulsion Laboratory, Pasadena, California

A scheme for organizing data on terrain-surface coordinates provides a compact representation of, and fast access to, these data for purposes of computerized rendering of stereoscopic images of the terrain as viewed by two cameras on a platform at a fixed location above the terrain. The scheme is called the "tangential polar map" ("TANPO map," for short) because it is based on the innovative concept of tangential polar coordinate systems described below.

A tangential polar (or TANPO) coordinate system is constructed around the camera orbit, which is a circle of radius

L , on which the two cameras are mounted at diametrically opposite points. Both cameras face in the same horizontal direction, which is perpendicular to the diametral line between them. In a TANPO coordinate system, a point outside the camera orbit in the horizontal plane that contains the cameras is represented as $P(r, \theta)$, where r is the length of a line through the point tangent to the camera orbit, and θ is the angle between this line and a reference direction. Figure 1 illustrates a left TANPO coordinate system, which is applied to the left camera; a similar right TANPO coordinate system is applied to the right camera.

In this scheme, each view intersects only a small range of θ , and each viewing ray converges to a constant- θ line very fast. Initially, the terrain data are represented as a height field sampled along r and θ . Therefore, the data base is a regular two-dimensional array and access to the data is generally provided along θ . The TANPO representation inherently accommodates the resolution requirements at all distances with a compact structure that can easily fit in the main memories of parallel computers. It also provides excellent locality for the data-access pattern of an image-rendering algorithm, so that there can be a close match between the data decomposition and the task decomposition. These features contribute to efficient access to terrain data and can be exploited to accelerate the rendering process by use of parallel processing. Even on a single data processor, the TANPO representation uses the memory hierarchy efficiently.

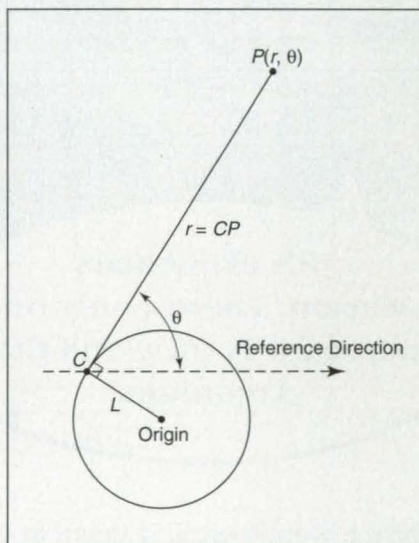


Figure 1. A TANPO Coordinate System bears some resemblance to a polar coordinate system in that it involves a range and an angle coordinate, but differs from a polar coordinate system except when $L = 0$.

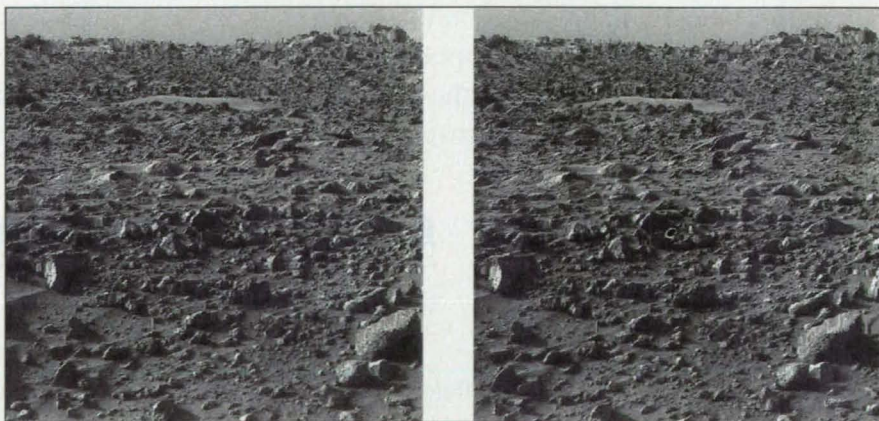


Figure 2. This Stereoscopic Pair of Images was rendered by the STREN computer program, using the TANPO map to represent terrain data abstracted from Viking lander images of the surface of Mars.

The TANPO map has been used to structure the database of STREN, which is a parallel-processing computer program that renders stereoscopic views of terrain by use of the ray-casting method (see Figure 2). The TANPO map can also be used as a basis for stereo environment maps to support image-based stereo rendering application programs.

This work was done by Ansel Teng of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 23 on the TSP Request Card.
NPO-19883

Electronic Data-Management System for Asbestos Survey

Data are organized in standard formats and made easily available.

John F. Kennedy Space Center, Florida

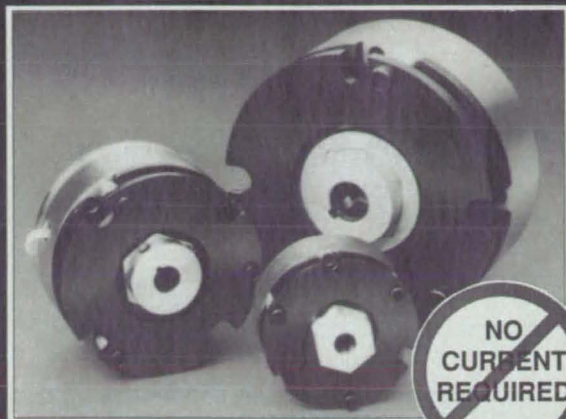
A system of computer hardware and software has been devised for use in surveying the asbestos contents of buildings at Kennedy Space Center. This is a partly automated, paperless system that replaces an older system in which inspectors made records on paper forms, and written reports of inspections were mailed to engineering and maintenance organizations. The system has obvious potential for adaptation to surveys of other large facilities constructed with building materials that contain asbestos.

The older paper-based system was inefficient in that reports were not available immediately after inspections, and inspectors had less time to spend performing inspections because they had to spend considerable time writing the inspection reports. Moreover, it was difficult to cross-reference and maintain paper files. Even in cases in which inspections had previously been performed, it took days to weeks to provide information because it was necessary to retrieve information from paper files, then write and mail reports. In addition, photographic documentation was not feasible because of a lack of means for fast reproduction of photographs for inclusion in written reports.

An inspector performs a survey according to asbestos-sampling rules prescribed by the Environmental Protection Agency. The inspector enters inspection data on a laptop computer; the data include the identity of the building, the room number, and the identity of each building material of interest. The inspector uses a computer-generated room grid to record the location of each identified material in a room; this technique expedites identification and location of materials of interest for subsequent closer inspection and sampling. Samples of materials of interest are sent to a laboratory for analysis of asbestos content by use of polarized-light microscopy. The inspector records the condition (including friability) of each material of interest, the asbestos content (if known) of the material, and an assessment of the hazard posed by asbestos if the material is friable.

Using an electronic still camera, the inspector takes digital photographs of materials suspected of containing asbestos. Digital photography offers several advantages over conventional film photography in this application: It is not necessary to process photographic film; the images are available immediately; the images can be digitally linked with the other inspection data on the building, room, and materials of interest; and the images can be readily transmitted and displayed electronically.

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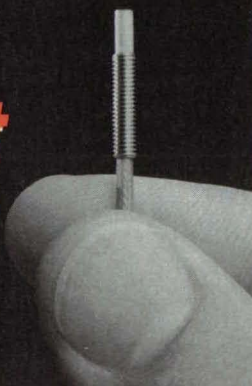
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The Facility Asbestos Management System (FAMS) © 1995 EG&G Florida, Inc., was developed by Larry D. Jewell, Steven W. Brown, Meredith R. Caukin, and James R. Taffer of EG&G Florida, Inc., for **Kennedy Space Center**. For further information, **write in 44** on the TSP Request Card.
KSC-11826

Algorithm for Proximity Detection on Parallel Processors

This algorithm helps processors track many moving objects and sensors.

*NASA's Jet Propulsion Laboratory,
Pasadena, California*

The Distribution List algorithm has been developed for use in proximity detection in parallel-processing computer simulations of movements of, and interactions among, a number of objects. The algorithm was originally intended for use in distributed interactive simulations of military situations like encounters of aircraft and missiles; it is also adaptable to virtual reality, simulation of colliding space debris, biological models, and models of particles interacting via short-range forces.

The algorithm is defined with respect to objects of two classes called "movers" and "sensors" (a mover can also be a sensor). The algorithm provides, to each participating sensor, continuously updated information on the locations and movements of the movers. The simulated space that contains the movers and sensors is represented by grids. Movers check in and out of grids while moving sensors periodically inform the grids of their coverage. Fixed sensors inform the grids only once, during initialization. Each grid manages a list of movers and a list of sensors operating in its space. The grids do not interact with each other.

The Distribution List algorithm is so named because each mover and sensor maintains a distribution list. In the case of a mover, the distribution list is a list of sensors that might detect its motion and that therefore need its equations of motion. When a mover checks into a new grid, it simultaneously checks out of its old grid. The new grid informs the mover of its current list of sensors so that the mover can update its distribution list.

Similarly, each sensor maintains a distribution list of grids within its coverage. When a sensor updates its coverage, it sends messages to new grids that are now in its coverage and to old grids that are no longer in its coverage. The grids then relay this sensor information to the movers in their mover lists so that the movers can update their distribution lists of sensors.

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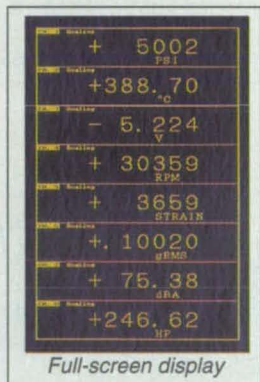
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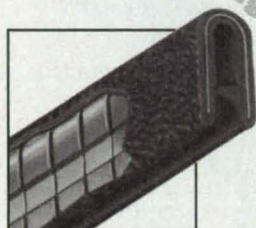
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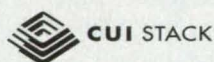
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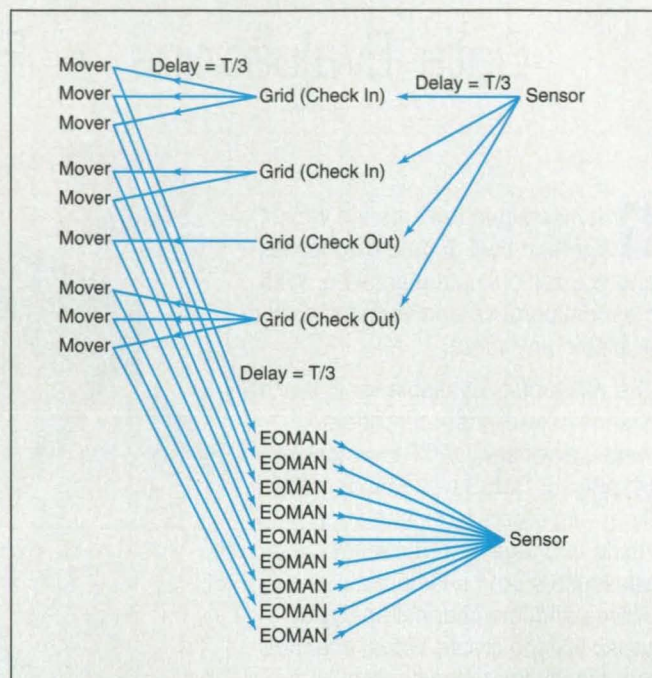
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Equation-of-motion managers (EOMANs) distribute the equations of motion of the movers to sensors represented in their local computing nodes (see figure). There are several EOMANs in each node so that a single EOMAN does not become a bottleneck for transfer of information. A mover chooses an EOMAN by use of a modular-arithmetic hashing scheme, then sends its equations of motion to that EOMAN.



In a **Representative Update of Grid Coverage**, a sensor finds that it has two new grids in its coverage and two old grids that are no longer in its coverage. These grids relay the sensor information to their movers, which then update their EOMANs in the computing node in which the sensor is represented. T denotes the total look-ahead delay in units of simulation time.

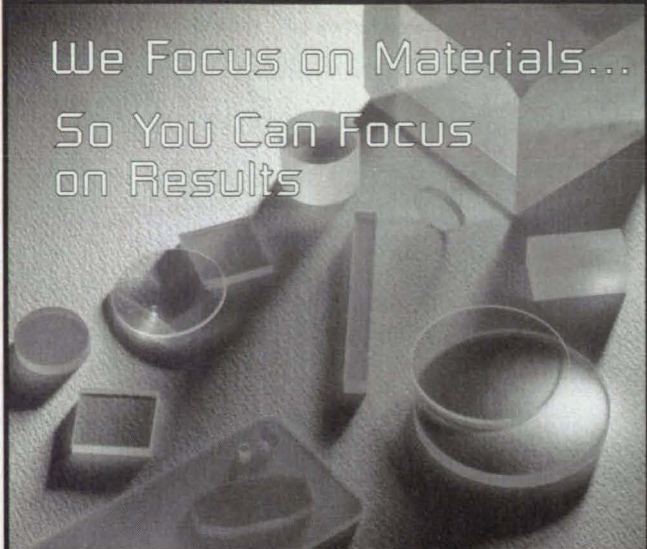
The Distribution List algorithm implements a look-ahead approach such that risk-free synchronization strategies never roll back grid events. In this look-ahead approach, fixed delays are added as events are scheduled for objects on other nodes. Zero delays are allowed for events scheduled between objects on the same node. As a result, sensors receive updates in some specified number of units of simulation time after a mover determines that it is in a new grid. To compensate for the delay, each sensor must extend its coverage by an amount equal to the distance traveled by the fastest mover during the delay time.

In a demonstration, The Distribution List algorithm was used in a simulation of 800 ground radars, 947 commercial aircraft, and 173 military aircraft flying randomly about the Earth. A grid size of 500 km was used to match typical sensor coverage. A total of 2,212,676 events were processed with only one roll-back (repetition of simulated event because of excessive delay). Only 34,437 messages were transferred between nodes, indicating that the algorithm maintains a good balance of events among grids.

This work was done by Jeffrey S. Steinman of Caltech and Frederick P. Wieland of MITRE Corporation for **NASA's Jet Propulsion Laboratory**. For further information, write in 45 on the TSP Request Card.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL; (818) 354-5179. Refer to NPO-19423.

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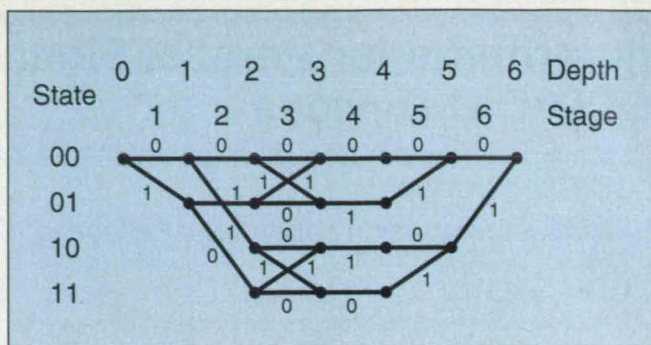
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is defined on trellises. If a trellis is optimum with respect to this partial ordering, then all the relevant measures of its complexity will be minimized. If the minimal trellises for two codes are comparable in terms of this partial ordering, then each of the complexity measures for one trellis is bounded by the same measure evaluated for the other trellis. This partial ordering can sometimes be used to identify (a) that permutation of a given code that yields the least (or most) complex minimal trellis, or (b) that code whose trellis is the most or least complex of all codes with the same parameters.

In the derivation of the present techniques, the trellis-complexity analysis for a fixed code lends itself naturally to generalization to codes that are allowed to vary. Two useful domains of optimization are the set of permutations of a given code and the set of all codes with given code parameters. Within each domain, the uniformly best and worst minimal trellises (when they exist) are guaranteed to simultaneously minimize or maximize all of the measures of complexity. Furthermore, if a minimal trellis attains the bounds for some of the complexity measures, it must necessarily be uniformly extremal, but this is not true for the simpler measures of maximum state or edge dimension explored in the prior art. This lends further credence to the argument that a measure of total complexity (such as the total number of edges) is more useful than is a measure of maximum complexity.

Unlike the case of a fixed permutation of a given code, uniformly best and worst minimal trellises are not guaranteed to exist within the larger domains of optimization. However, the usefulness of the present techniques has been demonstrated in several test cases that provide examples of uniformly best trellises—most notably, the optimum permutation of the (48,24) quadratic residue code, heretofore unknown. Conversely, by deriving some necessary existence conditions, some cases for which uniformly extremal minimal trellises cannot exist have also been identified.

A series of useful relationships between the trellis complexity of a given code and that of its dual have also been developed. This approach yields many of the same results obtained in previous research for dimension/length profiles or generalized Hamming weights, but it emphasizes that all the duality results stem from fundamental minimal trellis relationships valid for a fixed permutation of a code. In fact, the symmetry of the constraints imposed by the code and its dual on the complexities of the trellises is so fundamental that the minimum distance of the dual code should be included as one of the intrinsic code parameters that limits achievable complexity. This duality leads to interesting connections among several complexity measures for the special case of self-dual codes.

This work was done by Aaron B. Kiely, Samuel J. Dolinar, Robert J. McEliece, Laura Ekroot, and Wei Lin of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 89 on the TSP Request Card.
NPO-19601

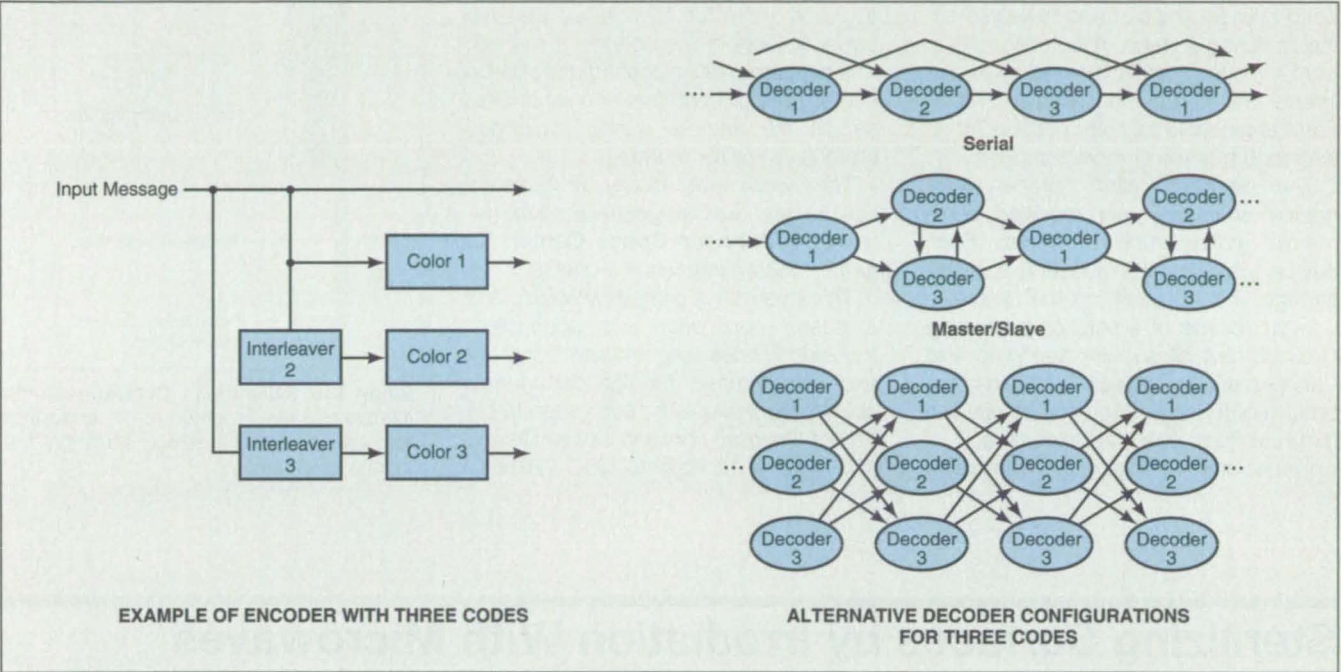
Turbo Coding and Decoding for Personal Communications

A proposed method would feature high speed and low cost.
NASA's Jet Propulsion Laboratory, Pasadena, California

A method of coding and decoding has been proposed to satisfy a need for fast-operating, relatively inexpensive coding and decoding circuitry for personal communications. A coding subsystem according to this method would

The second contribution is a technique for achieving better performance by use of unequal-rate component codes. Thus, each of the multiple parallel encoders would implement a different component code; in other words, the

master/slave (mixed serial/parallel), or parallel configuration (see figure). A turbo decoding subsystem according to the present method and based on an approximation to the optimum maximum a posteriori (MAP) rule would have to



Multiple Coded Versions of the Same Message would be generated by multiple coders operating in parallel, and decoded by multiple decoders in one of three alternative configurations.

include multiple binary convolutional coders in parallel, each coder preceded by an interleaver (a pseudorandom block scrambler with no repetitions), which would permute the incoming information prior to further coding.

Codes that combine multiple binary component codes with interleaving are called "turbo" codes. The turbo-code concept was first published in 1993, accompanied by a claim that turbo codes are capable of achieving near-Shannon-limit error-correction performance with relatively simple component codes and large interleavers. Recent research has confirmed the accuracy of this claim and has led to the present method, which incorporates three contributions beyond the basic turbo-coding concept.

The first contribution is a simple technique for trellis termination. This technique involves turning off the input information during a portion of each code block to flush the encoders with zeros.

coding subsystem would generate different encoded versions of the same input message — one for each component code. The component codes would feature very short code constraint lengths, and the interleavers would be small. The smallness of the interleavers would contribute to satisfaction of the requirement for delay.

The third contribution is the development of decoders for multiple-code encoders, so as to accommodate the unequal-rate component codes. A decoding subsystem according to the present method would include multiple decoders corresponding to the number of codes, linked together to feed back to each other and iterate until the required accuracy was achieved. The original turbo decoding scheme for the case of two codes called for pure serial decoders, but depending on the design of a specific decoding subsystem according to the present method, the decoders could be linked in a series,

operate in the parallel mode. The shortness of the constraint lengths of the codes would contribute to satisfaction of the requirement for low cost by reducing the complexity of the decoders.

This work was done by Dariush Divsalar and Fabrizio Pollara of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 42 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-19634, volume and number of this NASA Tech Briefs issue, and the page number.



Preservative-Coated Salivettes

Saliva samples can be preserved at room temperature for as long as six months.

Lyndon B. Johnson Space Center, Houston, Texas

An improved device for collecting and storing saliva samples eliminates the need to freeze the samples to keep them stable during storage. Invented for use in the Space Shuttle/Mir biomedical experiments, the devices can also be used on Earth to preserve samples of saliva for as long as 6 months at room temperature.

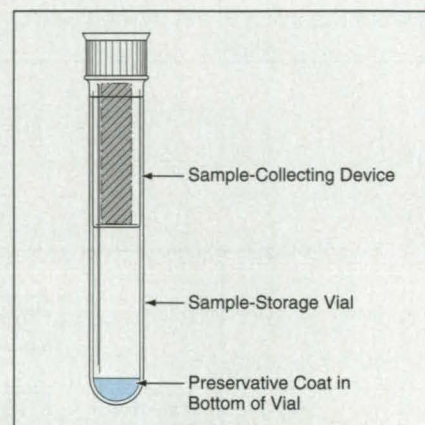
The devices, called "preservative-coated salivettes," are modified commercial saliva-sampling devices. Each device (see figure) includes a sample-storage vial. In modifying the device, a 0.2-mL volume of a solution containing 0.25 percent of sodium benzoate and 0.05 percent of citric acid is placed in the bottom of the vial, then vacuum dried to form a uniform coat of preservative.

Immediately after taking a sample of

saliva, the preservative-coated salivette that contains the sample is centrifuged at 3,000 r/min for 10 min, so that the saliva collects in the bottom of the vial. The dry preservative coating dissolves in saliva during centrifugation and preserves the sample during prolonged storage (up to six months).

This work was done by Lakshmi Putcha and Ramalingeshwara Nimmagudda of **Johnson Space Center**. No further documentation is available.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22616.



When the Salivette Is Centrifuged, the sample of saliva is forced to the bottom of the vial, where the saliva dissolves the preservative coat.

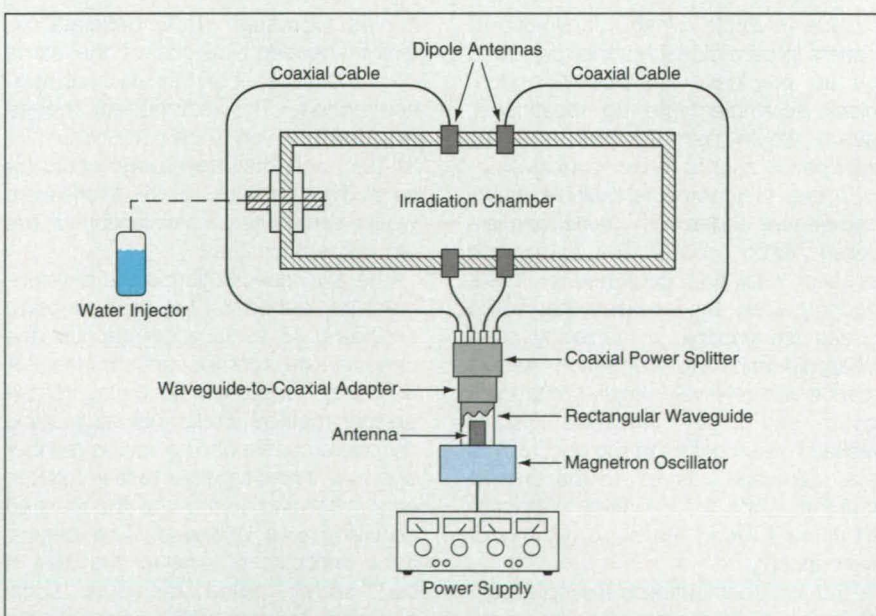
Sterilizing Surfaces by Irradiation With Microwaves

A variety of bacteria, yeasts, and molds can be killed by this technique.

Lyndon B. Johnson Space Center, Houston, Texas

A technique for sterilizing equipment surfaces involves bombarding the surfaces with microwaves at a frequency of 2.45 GHz, in the presence of trace amounts of water (see figure). This technique was devised to overcome some of the limitations of older sterilization techniques: the high temperatures needed for autoclaving can damage some equipment, irradiation with g rays cannot sterilize all parts of some complexly shaped objects, and sterilizing chemicals can become unacceptable contaminants in some applications. The microwave-based sterilization technique is not subject to these limitations, and has obvious potential for use in the food, drug, and beverage industries.

The reason for using a frequency of 2.45 GHz is that photons of this frequency couple directly with transitions between rotational quantum states of water molecules. Thus, water molecules present in small quantities can be activated directly by microwaves to sterilize



Water Molecules in Trace Amounts are energized by microwaves at a frequency of 2.45 GHz, which couples directly to a rotational quantum transition of water molecules. The energized molecules sterilize surfaces with which they come in contact.

surfaces, with minimal heating of the surfaces. Microwave irradiation of dry surfaces has proven capable of killing microorganisms. Active vegetative microbial cells contain water. Microwaves of sufficient intensity and duration penetrate microbial cell walls, couple with the water inside, and kill the microbes by internal heating.

Spores are relatively resistant to dry microwave irradiation because they contain little or no free water with which the microwaves can couple. Spores and resistant organisms can be destroyed by introducing water in quantities of the order of 9 microliters per square centimeter of contaminated surface. By direct absorption of microwave energy, the water flashes to steam, which makes contact with all exposed surfaces, killing the organisms there. This effect is localized, and, because of the smallness of the amount of water used, little energy is transferred into the sterilized equipment.

This technique has proven effective in sterilizing surfaces contaminated with a variety of bacteria, yeasts, and molds. In experiments, mixed surface populations of *Bacillus pumilus*, *Escherichia coli*, and *Pseudomonas Cepacia* were killed by 0.76 W-hr/cm² of exposure to 2.45-GHz microwaves at a power density of 3.6 W/cm². Experiments have also shown that sterilization can be achieved even when the microwaves have to pass through elastomeric materials on their way to the equipment to be sterilized; thus, the technique can be used to sterilize fully enclosed systems.

This work was done by Duane Pierson and Richard L. Sauer of Johnson Space Center and James E. Atwater, Neil D. Streech, Frank C. Garmon, and Robert K. Ames of Umpqua Research Co. For further information, **write in 54** on the TSP Request Card.

MSC-22484

Pediatric Oncology Telemedicine Project

Children in a medically underserved region now have access to cancer specialists.

*Dryden Flight Research Center,
Edwards, California*

NASA has helped to create a telemedicine link between the University of Texas Health Science Center at San Antonio (UTHSC-SA) and South Texas Hospital (STH) in Harlingen, Texas. This link is designed to help indigent Hispanic children with cancer who reside in regions of South Texas near the Mexican border, where there is no consistent access to pediatric oncology specialists.

Telemedicine serves as a means for making better patient-management decisions by enabling pediatric subspecialists to perform direct visual examinations of children. Examination of blood smears and bone-marrow-aspiration slides over a telemedicine link by an expert provides more accurate information for assessment and management of patients. Telemedicine improves the accuracy of triage, without requiring that children travel to San Antonio for this purpose. Finally, telemedicine provides greater access to such ancillary services as nursing education, patient/family education, and psychological counseling.

Soon after the telemedicine link was established for pediatric oncology purposes, the physicians at STH requested consultations with a tuberculosis expert because of the large number of complicated tuberculosis cases seen at their institution. A specialist in adult pulmonary tuberculosis was located at the San Antonio State Chest Hospital and she agreed to continue to pro-

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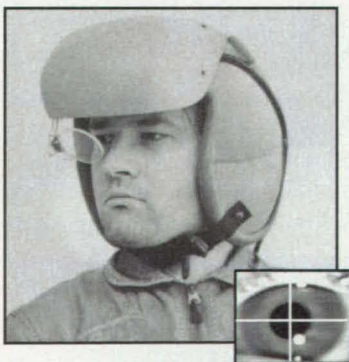
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vide consultations on tuberculosis in adults with the physicians at STH via the telemedicine system.

The main equipment of the telemedicine system is two videoteleconferencing units connected by a T1 communications line. One unit is located within the Department of Pediatrics at UTHSC-SA, while the other is located in the outpatient clinic at STH. The telemedicine system also includes two auxiliary input units; (1) a document camera for transmission of rudimentary x-ray images and (2) a microscope camera that enables the transmission of bone-marrow-biopsy slides.

Since inception of the Pediatric Oncology Telemedicine Project in April of 1995, the system has been used on 31 occasions. Most sessions are scheduled so that a number of patients can be discussed at one time. Thus, during these 31 sessions, consultations about a total of 236 individual patients have occurred. Initial consultations consisted of discussions about patients by physicians and nurses on both ends of the link. More recent consultations have included visual

inspections of patients by use of the video component of the system. Anecdotal evidence suggests that patients, consultants, and referring physicians are highly satisfied with the system.

The future of this telemedicine project looks bright. UTHSC-SA has secured funding to continue this link once support from the initial consortium is terminated. Additional funding is being sought for such future enhancements as (1) electronic examination tools to enable more detailed examinations of patients via the link and (2) better facilities for transmitting x-ray images.

This work was done by Lee Duke and Reuben Cano (CSC) of Dryden Flight Research Center, Raul Mejia of Johnson Space Center, Michael Weingarten of NASA Headquarters, James Legler and Frank Stafford of the University of Texas Health Science Center at San Antonio, Brady Bruce of VTEL Corp., and Jerry Raggett of Sprint Corp. No further documentation is available. DRC-96-03

Nonintrusive Manipulation of a Detached Retina

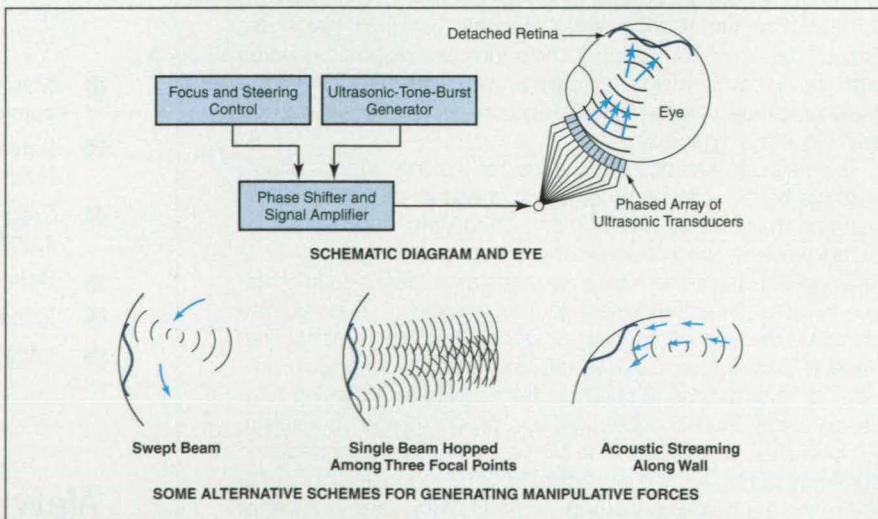
Focused ultrasound would provide small manipulative forces.

Lewis Research Center, Cleveland, Ohio

In a proposed technique for surgical manipulation of a detached retina, ultrasound would be generated outside the eye and coupled into the eye to generate small manipulative forces (see figure). The technique would involve no incisions or other penetrations by solid objects, unlike

older techniques that involve insertion of needles or other devices, with consequent additional trauma, discomfort, and opportunity for infection.

The technique would exploit acoustic-radiation pressure, which is a second-order effect that arises from nonlinear



An **Ultrasound at High Intensity** at a desired location inside the eye would be generated by convergence of lower-intensity beams of ultrasound from a phased array of transducers in contact with the outer surface of the eye.

behavior of the acoustic medium (in this case, the fluid in the eye) and that becomes evident when sound is at high intensity. In the presence of low-intensity sound, acoustic pressure at a given location varies sinusoidally with time, so that its average over time is zero. In high-intensity sound, the variation with time is not precisely sinusoidal, and there is a small nonzero time-averaged component, which constitutes the acoustic-radiation pressure.

The basic idea in the proposed technique is to generate acoustic-radiation pressure inside the eye, near the location of detachment, to push the retina back into its correct position. Acoustic streaming — another small effect that accompanies acoustic-radiation pressure — could also be exploited to produce manipulative forces indirectly; for example, as shown at the bottom of the figure, the hydrodynamic force exerted on the retina from fluid streaming along the wall could push the retina against the wall. The flow along the wall would also help in displacing fluid from behind the retina, thereby helping to flatten the retina against the wall.

One or more ultrasonic signal(s) would be generated by external electronic circuitry and coupled into the eye via one or more ultrasonic transducer(s) in contact with the outer surface of the eye. Because high-intensity ultrasound could damage the outer surface of the eye, the ultrasound would not be generated at high intensity; instead, it would be generated in a relatively broad, low-intensity beam that would be focused to high intensity at the required location inside the eye (see figure).

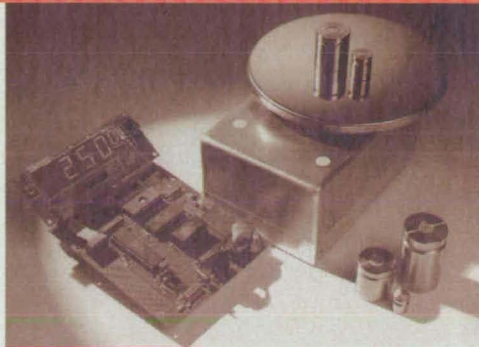
Preferably, many transducers would be assembled in a phased array, and the phases of the ultrasonic tone burst applied to the transducers would be controlled individually to steer and focus the beam to the desired position. If the phase-control subsystem could produce suitable phase sweeps and abrupt steps, then it would also be possible to perform such operations as sweeping the focused ultrasonic beam over an area or making the beam jump, repeatedly and rapidly, to among several focal points so that the net effect would be that of multiple beams pushing on the retina at different locations simultaneously.

This work was done by Richard C. Oeftering of Lewis Research Center. For further information, write in 63 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: James Martz, Mail Stop 7-3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16189.

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Physical Sciences

The Pebble Bed Heater at Stennis Space Center

A brief report presents additional information on the subject matter of "The High Heat Flux Facility at Stennis Space Center" (SSC-00033), *NASA Tech Briefs*, Vol. 20, No. 7 (July 1996), page 56. The emphasis in the report is on a pebble bed heater that lies at the heart of the facility. The pebble bed heater includes a bed of stainless-steel balls through which hot nitrogen is passed to store heat in preparation for a test. At the time of a test, heat is suddenly released by passing hydrogen through the bed and into a test cell.

This work was done by William W. St. Cyr of Stennis Space Center and

Edwin P. Russo of the University of New Orleans. To obtain a copy of the report, "NASA John C. Stennis Space Center's Pebble Bed Heater," write in 60 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the NASA/SSC Technology Transfer Office; (601) 688-2346. Refer to SSC-00045.

Calculation of Optical Scattering by Axisymmetric Particles

Airborne dust and ice particles can absorb, emit, and scatter both solar and thermal radiation in planetary atmospheres. Because these processes can have dramatic effects on the atmospheric energetics and global circulation, effi-

cient, accurate numerical methods for computing their optical properties are essential components of global climate models. These methods are also needed for the retrieval of atmospheric temperatures and constituent distributions from remote sensing observations collected by satellites. Accordingly, a study has been performed to evaluate a numerical method for calculating the single particle scattering properties of axisymmetric aerosol particles with sizes that span the Rayleigh scattering (small particle) and geometric optics (large particle) regimes.

This work was done by Cinzia Zuffada and David Crisp of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Particle scattering in the resonance regime: a full-wave solution for axisymmetric particles with large aspect ratios," write in 41 on the TSP Request Card.

NPO-19916

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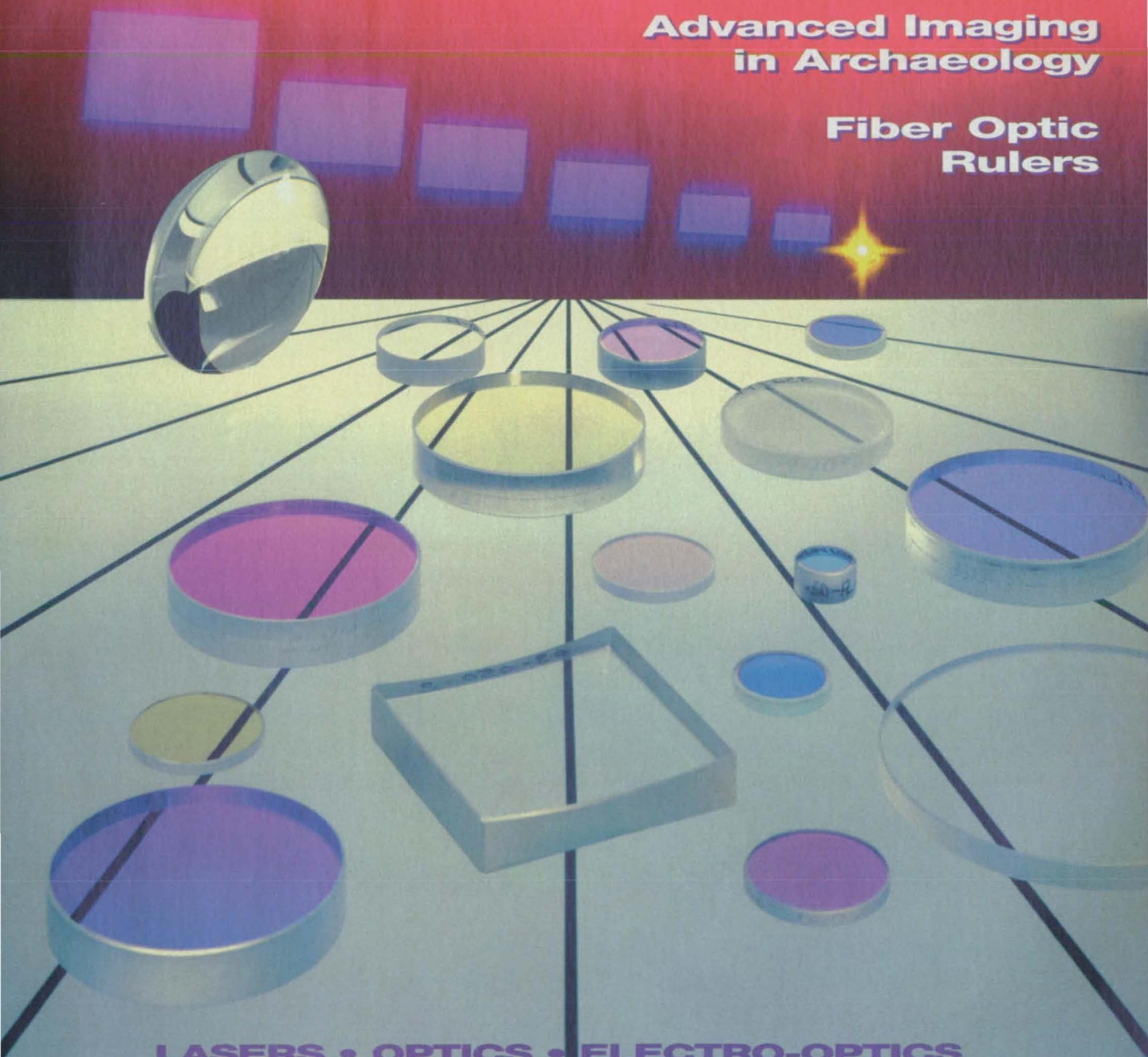
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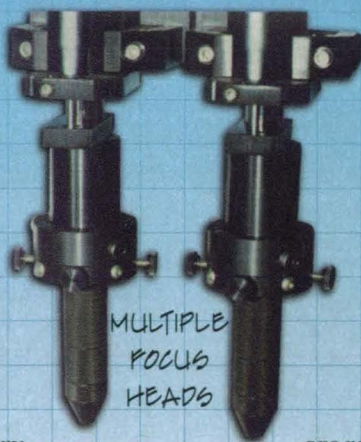
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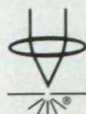
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LASER TECH BRIEFS

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On the cover:

The cover depicts Acton Research Corp.'s line of high-power laser optics and high-reflectance and antireflection coatings, designed for use with excimer and other ultraviolet lasers. *Photograph courtesy Acton Research Corp.*

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Apparatus for Fine Adjustment of Laser Beam

The size, position, and orientation of the beam waist can be adjusted nearly independently.

Ames Research Center, Moffett Field, California

Figure 1 illustrates an apparatus that enables fine optical adjustments of a highly collimated, axisymmetric laser beam with a Gaussian intensity pattern in its cross section. The apparatus is especially useful for launching the beam into an optical fiber by focusing the beam onto one end of the fiber.

The apparatus provides adjustments of six parameters of the laser beam: (1) the diameter of the beam waist (typically required to be narrow enough to match the core of the optical fiber), (2) the position (z) of the beam waist along the optical axis (typically required to be the axial position of the end of the optical fiber), (3 and 4) the position of the beam waist along the two coordinates (x and y) transverse to the optical axis, and (5 and 6) the angles of incidence (in the z - x and z - y planes) of the beam on the target (the end face of the optical fiber). In addition, the apparatus preserves the polarization adjustment (if any) provided by external means.

The design of the apparatus involves a convergence of Gaussian and geometric optics; that is, the focal lengths of the lenses and the distances between the lenses and the other optical components are chosen so that, with respect to demagnification and positioning of beam waists, the behavior of the apparatus conforms approximately to the equations of geometric optics despite the Gaussian nature of the laser beam. This design choice provides for fine optical control of the angles (adjustments 5 and 6) independent of the other parameters. Moreover, the focal lengths and distances are chosen to take advantage of optical leverage, analogous to mechanical leverage, that enables the use of relatively coarse mechanical adjustment devices (the micrometers that position the lenses) to adjust the lateral position of the beam waist on the target to a resolution as small as a fraction of a micron.

The axial positions of lenses 1 and 2 both affect the diameter and axial position of the output beam waist, but the design choice of focal lengths and distances makes it possible to use lens 2 to adjust primarily the axial position, with little effect on the diameter. A typical sequence of adjustments (see Figure 2) of an initially angularly and translationally misaligned beam begins with the coarse transverse and axial positioning of the end of the optical fiber. Lens 2 is then adjusted axially to position the output

beam waist axially in the plane of the end of the fiber. Next, lens 1 is adjusted transversely to make the output beam intersect the end of the fiber more precisely in translation, albeit at an undesired angle. Then the flat plate is tilted to adjust the angle of incidence. This sequence is repeated, as necessary, to refine the adjustments.

This work was done by Dana Lynch and Kenneth McAlister of **Ames Research Center** and William Gunter of

Photon Application. For further information, **write in 46** on the TSP Request Card.

This invention has been patented by NASA (U.S. Patent No. 5,077,622). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-11916.

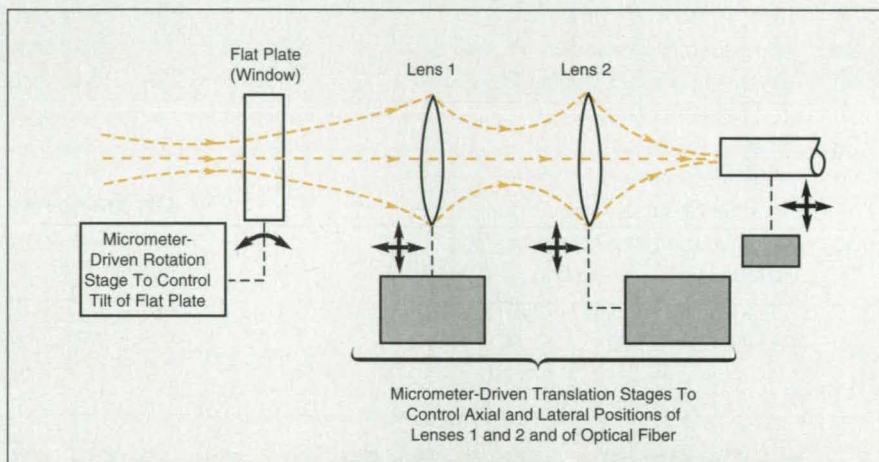


Figure 1. This **Apparatus Enables Fine Adjustments** of the size, position, and orientation of the output beam waist to focus the beam onto the end of the optical fiber.

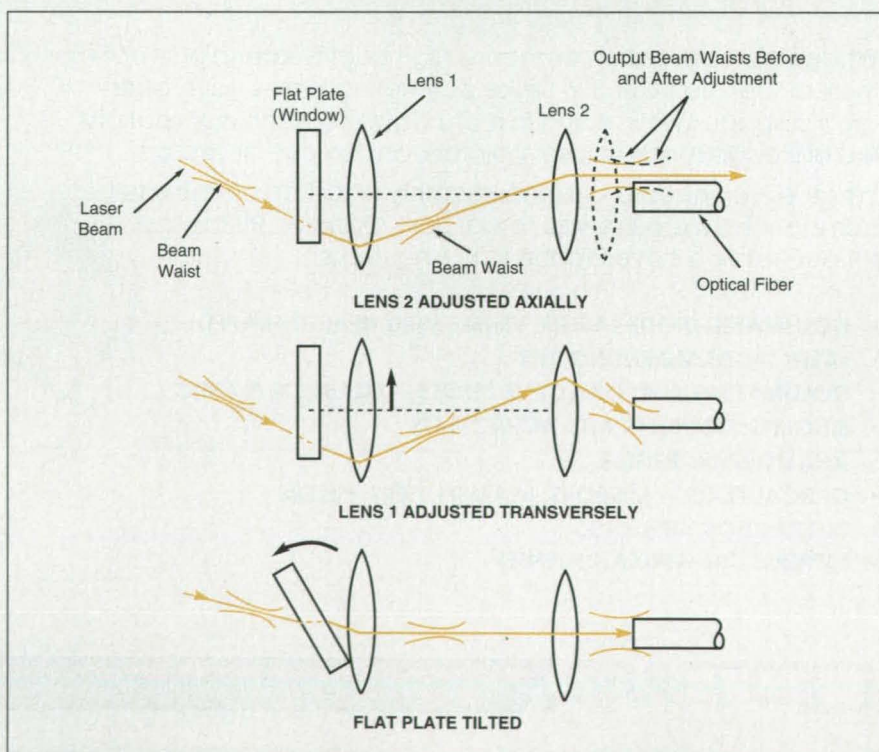


Figure 2. A **Sequence of Adjustments** results in alignment of a laser beam with the input end of an optical fiber.

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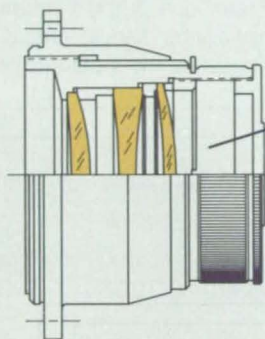
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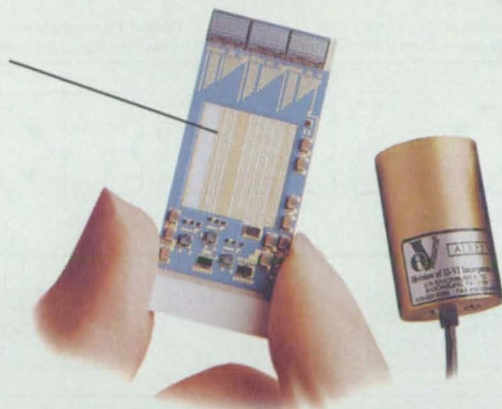
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Video Ground-Isolation Circuit Using Double Balanced Mixers

Advantages are reduced weight and cost.

Lyndon B. Johnson Space Center, Houston, Texas

An improved circuit has been developed to provide isolation of grounds at the video-signal interface between wide-baseband video-signal-processing equipment and other video-signal-processing equipment. Previously, video transformers and, alternatively, optical isolators have been used for this purpose. The disadvantages of video transformers are that they are heavy and expensive; optical isolators are expensive and must be recalibrated periodically because of long-term drifts of parameters of components. In comparison with video transformers and optical isolators, the present circuit is smaller and more cost-effective.

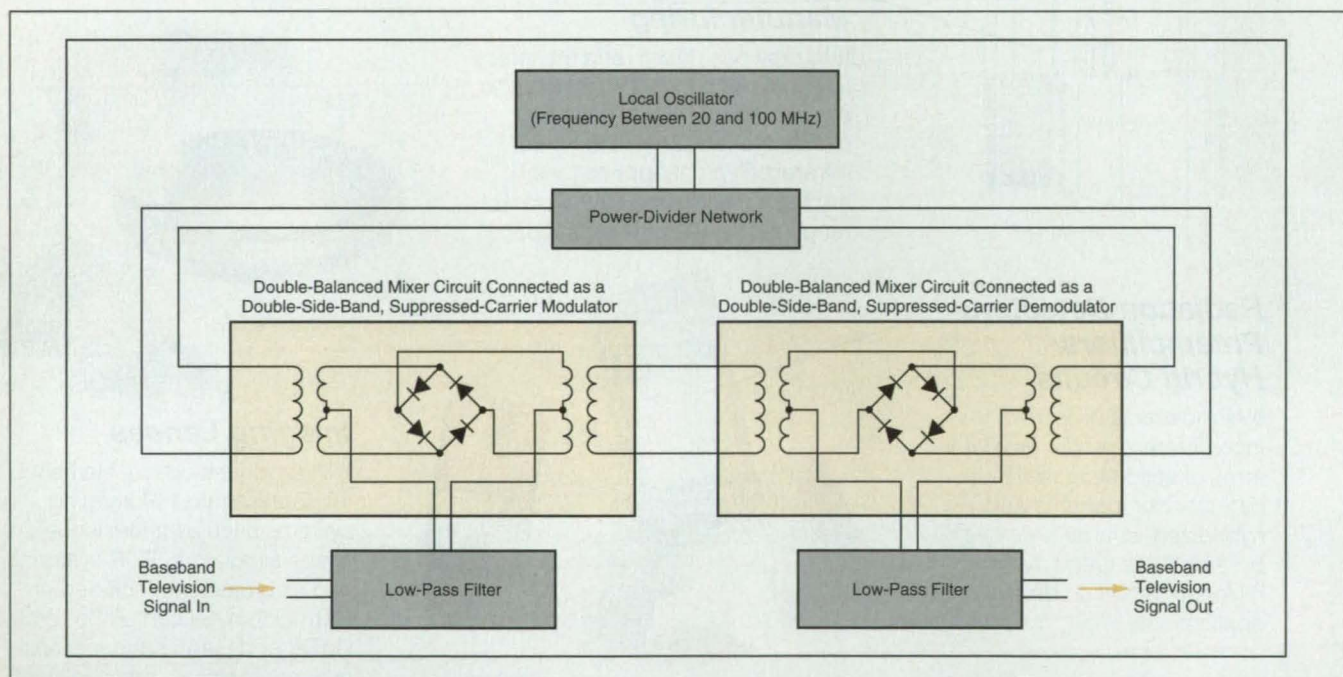
are transformer-coupled for isolation of ground potentials. This configuration also isolates the ground of the local oscillator from the video input and output circuits.

The fundamental video ground-isolation circuit consists of the parts described above. The power-divider circuit between the local oscillator and the mixers and the low-pass filter at the input and output ends help improve the performance of the fundamental circuit.

Baseband-signal frequency components from direct current up to a frequency limited by the frequency of the local oscillator frequency can be recovered at the output end. Theoretically, to

V peak-to-peak, it may therefore be necessary to add a voltage-divider network at the input end and a video amplifier at the output end to enable the use of this circuit as an interface circuit for NTSC standard signals. Alternatively, another commercial mixer such as a Mini Circuits RAY-1 may operate at a higher signal level, so that conversion of the signal level would not be necessary.

A laboratory signal generator was used as the oscillator in the prototype, but the final design will call for an on-board local oscillator. Neither long- nor short-term drift in the frequency of the local oscillator should create any difficulty because the local-oscillator signal



This **Video Ground-Isolation Circuit** costs less than does a conventional video transformer or optical isolator.

This circuit (see figure) includes two typical double balanced mixer circuits (Mini Circuits SRA-1 or equivalent), and a local oscillator. The double balanced mixer at the video-input end serves as a double-side-band suppressed-carrier amplitude modulator. The double-side-band output of the modulator is fed across the interface to the other double balanced mixer, which serves as a demodulator. The same local-oscillator signal is used in both the modulator and the demodulator to provide for phase-synchronous demodulation. All three ports of each double balanced mixer

enable complete recovery of the baseband signal, one must make the frequency of the local oscillator at least twice the highest frequency present in the baseband signal. In a practical application, the frequency of the local oscillator should be much more than twice the highest baseband frequency.

A prototype of the circuit was constructed with the commercial double balanced mixer circuits mentioned above. In a test, the mixers operated linearly up to about 0.5 V peak-to-peak. Inasmuch as the National Television Systems Committee (NTSC) standard level is 1.0

serves as the reference signal in both the modulating and the demodulating mixer.

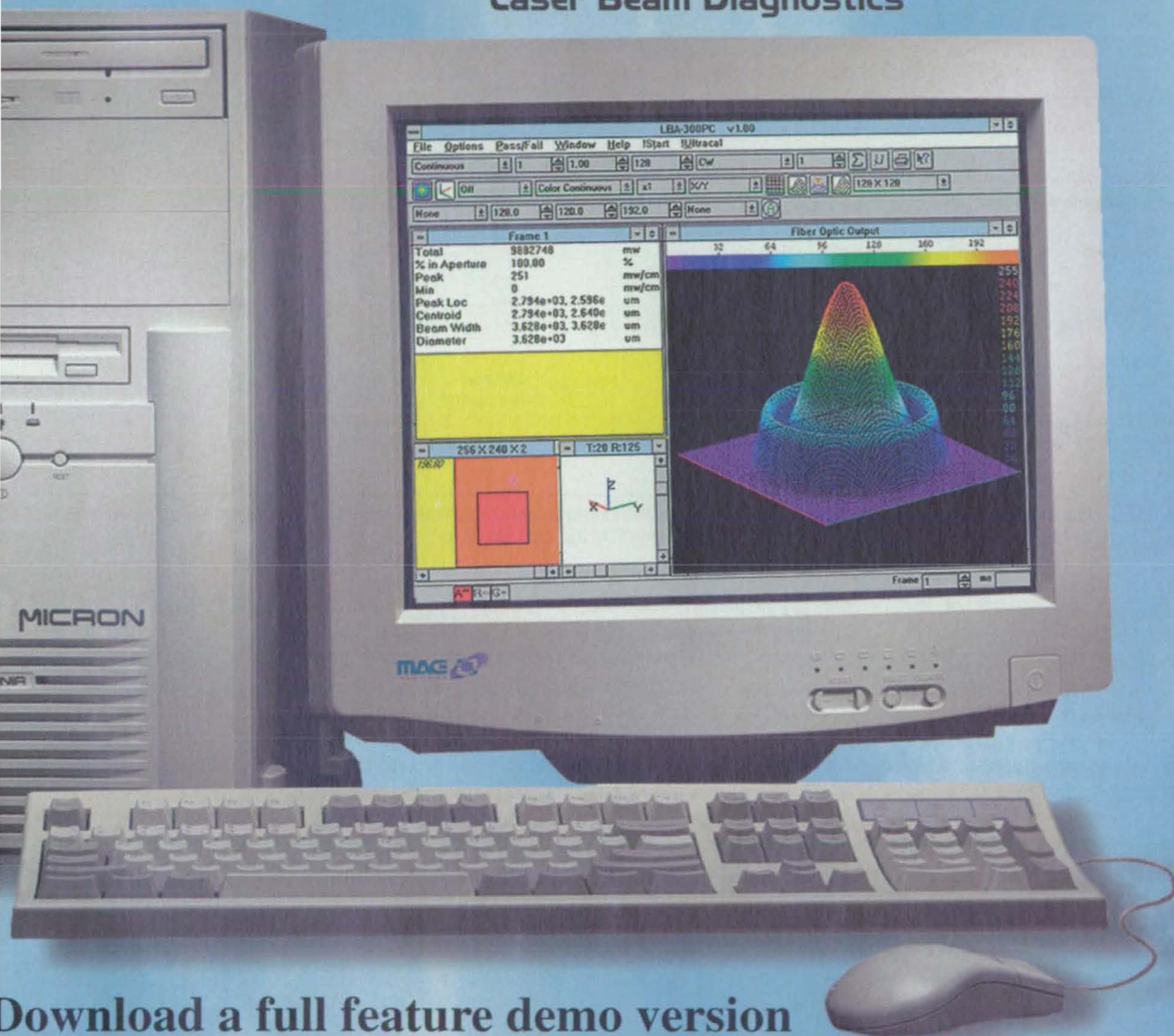
This work was done by Craig A. Davidson of Hernandez Engineering for Johnson Space Center. No further documentation is available.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22521.

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Confocal Telescope for Optical Sensing at Finite Distances

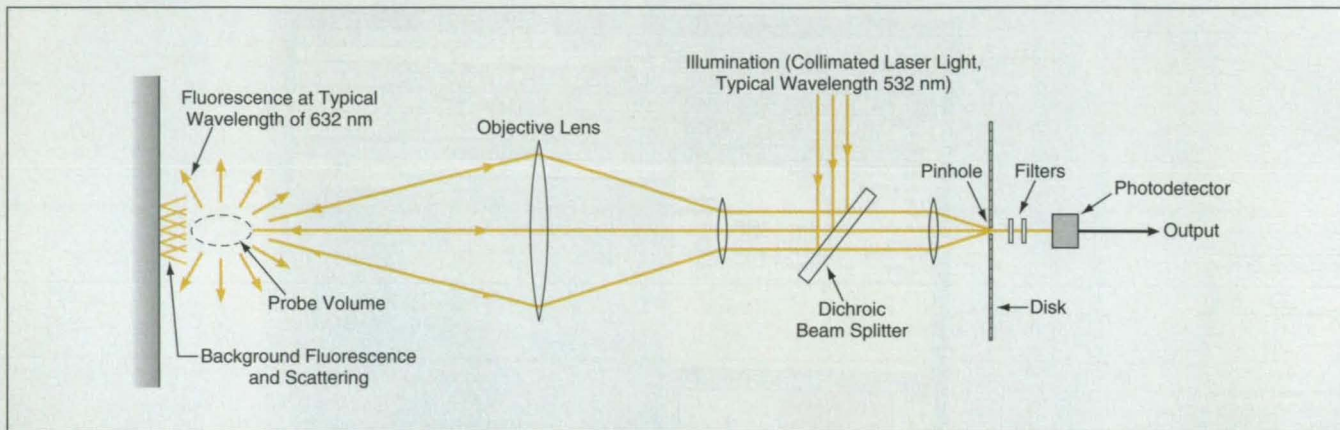
Only light from a small probe volume would be strongly coupled to a photodetector.

Marshall Space Flight Center, Alabama

A confocal telescope has been proposed for use in spatially resolved fluorescence measurements on transparent and semitransparent samples at distances up to a few meters. The samples could be, for example, streams of hot exhaust gases or process streams that one seeks to analyze without inserting probes.

When the fluorescence signal is weak (as is commonly the case), the measurement can be severely contaminated or even overwhelmed by (1) backscattering of the illumination from the probe volume and (2) spurious fluorescence from background objects outside the probe volume. Time gating of the illumination and of the detector operation

ing modifications of focal lengths, magnification, and aperture sizes. Light originating from a focal point at the center of the designated probe volume would be focused into the center of a pinhole immediately in front of the photodetector. Light originating from outside the probe volume would be focused elsewhere, such that most of it would be intercept-



The **Confocal Telescope** would focus light from the probe volume onto the photodetector. Light originating elsewhere would be severely attenuated on the way to the photodetector in that most of it would be blocked by the pinhole disk.

Typically, in a measurement of this type, one illuminates a small probe volume with a focused beam of light of known wavelength to excite fluorescence at a longer wavelength, and seeks to measure the longer-wavelength fluorescence emitted from the probe volume only, using a photodetector. By repeating the measurement while scanning the probe volume through the sample in three dimensions, one can acquire data on the three-dimensional distribution of the quantity of interest.

can provide some relief but is not sufficient in many cases. In the confocal telescope, most of the backscattered illumination and fluorescence coming from points outside the probe volume would be blocked on the way to the photodetector, and the backscattered illumination from throughout the sample (including the probe volume) would be suppressed by optical filters.

Basically, the confocal telescope (see figure) would be a distorted version of a confocal microscope, with correspond-

ed by the pinhole disk before reaching the detector. A calculation based on geometrical optics reveals that the fraction of light reaching the photodetector from a point outside the probe volume would be approximately proportional to the inverse square of the distance of that point from the center of the probe volume.

This work was done by Thomas W. Duryea of Rockwell International Corp. for Marshall Space Flight Center. For further information, write in 34 on the TSP Request Card. MFS-30106

Optically Powered Stroboscopic Warning Light on a Power Line

Power is supplied via an optical fiber from a unit at ground level.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optically powered strobe lamp is designed to be mounted on a power line, midway between supporting towers, to give visible warning to aircraft pilots. Power is transmitted from a unit at ground level, via an optical fiber, to a strobe-lamp unit up on the power line.

Although it is easy to equip the supporting towers with warning lights, it is difficult to illuminate power lines between towers. In principle, a strobe light mounted on a power line could be inductively powered by the line current; however, the iron core of an inductive

pickup device would weigh too much and, in any event, the light would not operate when the line current was turned off. A solar-powered strobe light with storage battery would also be too heavy; and even if it were sufficiently lightweight, access for maintenance

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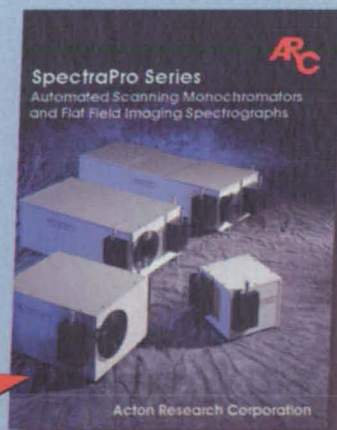
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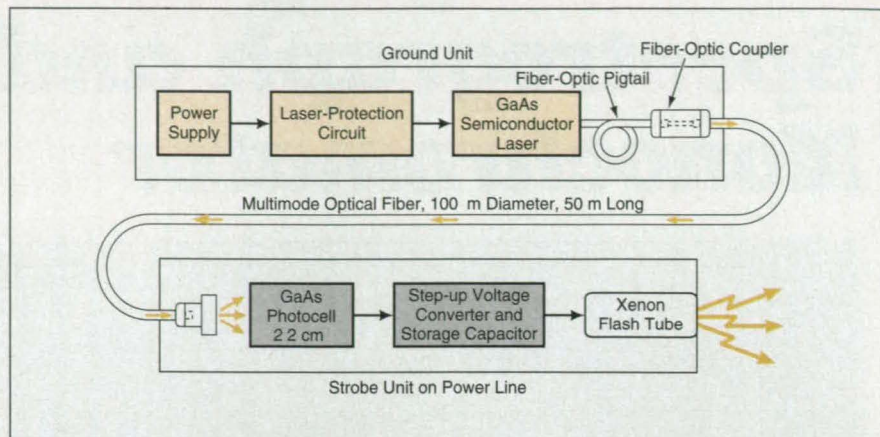
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would be too difficult. Finally, although an independently powered electrical line could be run from the ground to the strobe, insulating it from the high-voltage transmission line would be virtually impossible. On the other hand, an optical fiber is unaffected by the intense electric field of the power line.

In the present strobe-lamp system, light is generated by a gallium arsenide laser with a power of 0.85 W. A multimode optical fiber 100 μm in diameter and 50 m long carries the light from the laser to a gallium arsenide photocell in the strobe-lamp unit. The output of the photocell (at a potential of 0.9 V and current of 200 mA) is fed to a step-up voltage converter and storage capacitor for driving a xenon flash tube. The entire strobe unit weighs only 3 oz (85 g). A much brighter strobe would not necessarily weigh much more.

This work was done by Shannon P. Jackson of Caltech for NASA's Jet Propulsion Laboratory. For further infor-

mation, **write in 71** on the TSP Request Card. NPO-19668



The **Xenon Flash Tube Is Powered by Light** that is delivered via the optical fiber, then converted to electricity by the photocell. The step-up voltage converter and capacitor provide electrical pulses to energize the flash tube at frequent intervals.

Texture Etching of Indium Phosphide

Textured surfaces on photovoltaic cells enhance absorption of light.

Lewis Research Center, Cleveland, Ohio

A technique for texture etching of indium phosphide has been developed. As its name suggests, texture etching is a method of chemically treating the surface of a material to impart a desired texture. In recent years, texture etching has been investigated for use in forming microscopic V-grooves or pyramids on the surfaces of semiconductor materials in solar photovoltaic cells. These surface textures can decrease the reflection of light from the cells, thereby increasing the absorption of light in the cells, with consequent increases in energy-conversion efficiencies.

Texture etching is based on the anisotropic-etching properties of crystalline materials; the rates of chemical attack depend on orientations of etched surfaces with respect to crystalline planes. Texture etching has been applied to silicon, but heretofore, application to indium phosphide has been inhibited by greater difficulty that arises from the greater complexity of the anisotropy of etching indium phosphide in comparison with that of silicon. The greater complexity includes dependence of the etching behavior of InP on the type (p or n) and concentration of dopant.

The present technique for texture etching of InP was developed in experiments in which the effects of various factors (etching time, temperature, and

type and concentration of dopant) were recorded for use in controlling the outcomes of subsequent etches. The etching solution used in this technique is a mixture of 10 parts of (49 percent HBr in H_2O), 1 part of (31 percent H_2O_2 in H_2O), and 1 part of (38 percent HCl in H_2O). The etching solution is maintained at constant low temperature (usually, -20°C). A wafer to be etched is precooled to the etching

temperature before immersion in the solution. Typical etching times range from 30 s to 6 min.

The rate of etching and the resultant surface texture depend strongly on the etching time and on the doping. Etching by this technique produces irregular V-grooves (see figure) or pyramids on (100) InP wafers, without need for photolithography or masking to define the grooves or pyramids. The grooves are generally aligned along the [10] direction. Grooves etched on the front surface of a wafer are perpendicular to those etched on the rear surface. The characteristic widths and depths of the grooves are of the order of microns. The smallest groove spacing is about half a typical wavelength of visible light, and grooves as fine as this cause visible diffraction of white light.

This work was done by Sheila G. Bailey of **Lewis Research Center** and David S. Fatemi and Geoffrey A. Landis of NYMA, Inc. For further information, **write in 70** on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135.

Refer to LEW-15784.



This **Scanning Electron Micrograph** shows V-grooves produced by 4 min of etching of the (100) surface of a highly p-doped (2.8×10^{18} atoms of Zn per cm^3) InP wafer.

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Determining Fiber Volume Fraction by Image Analysis

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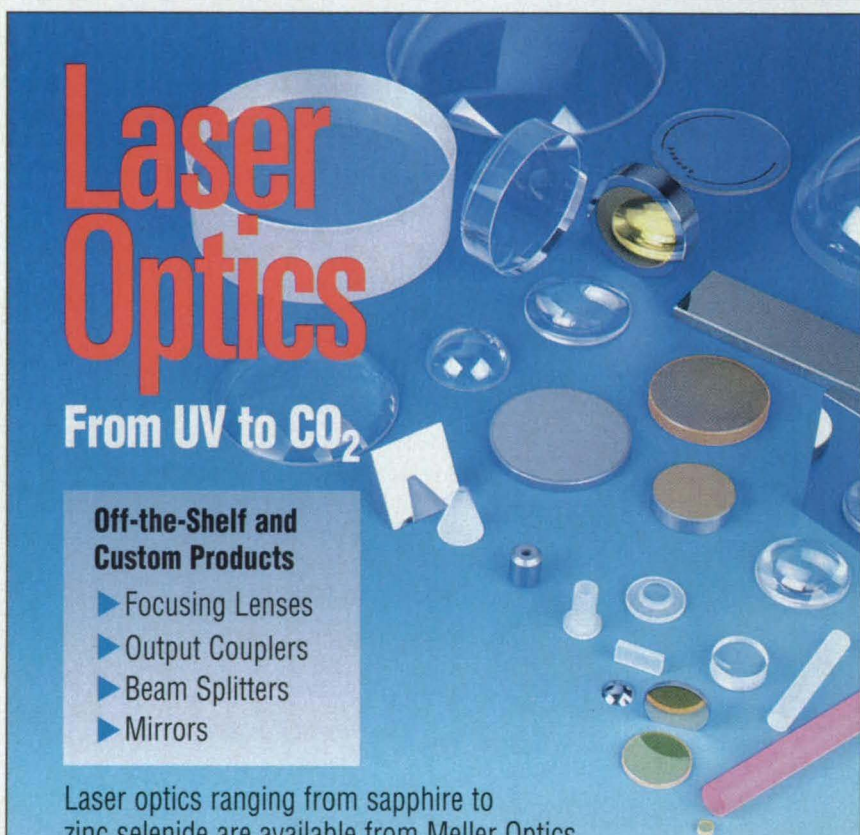
Goddard Space Flight Center, Greenbelt, Maryland

Experiments have shown that volume fractions of graphite fibers in graphite/epoxy materials can be estimated by analyses of images of sectioned specimens. Heretofore, the standard technique for determining the volume fraction of fibers has involved digestion in boiling nitric acid (to remove the epoxy matrix), followed

by washing of the fibers (which remain after digestion) in acetone. The acid-digestion technique adversely affects the environment in two ways: the process of digestion generates fumes that may not be captured completely in the condenser that is part of the digestion apparatus, and more than 200 mL of chemical waste are pro-

duced for each gram of specimen.

Recent advances in personal computers, imaging equipment, and image-analyzing software have made the image-analysis method a viable alternative to digestion in acid. A specimen is sectioned, mounted, and polished by standard metallographic techniques, then examined by use of a video camera mounted on a microscope, using a typical magnification of 1,000 (see Figure 1). The image is digitized, then



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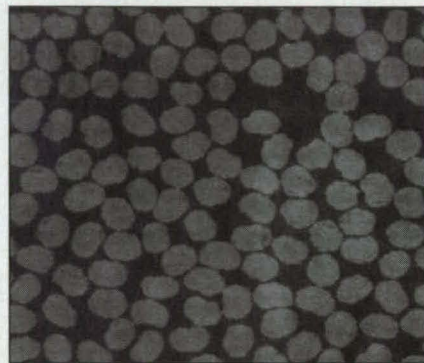


Figure 1. Cross Section of a Graphite-Fiber/Epoxy Specimen shows fibers nominally perpendicular to the plane of the section. The thickness of each fiber is about 5 μ m.

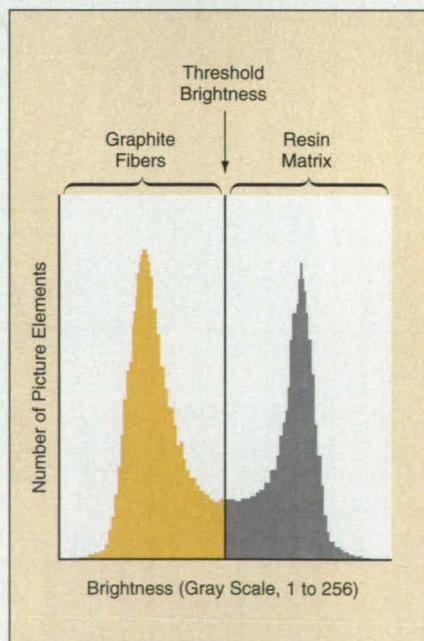


Figure 2. This Histogram shows the statistical distribution of brightnesses of the picture elements in Figure 1. To minimize the effects of errors in computer analysis of the image, the threshold level is set in the valley between the two peaks.

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analyzed semiautomatically on a personal computer by the "NIH Image" public-domain computer program, which was created at the National Institutes of Health.

The program distinguishes between the fiber and resin areas of the image by determining which picture elements are brighter and which are darker than a statistically determined threshold brightness (see Figure 2). The numbers of picture elements above and below the threshold level are counted. The area fraction of fibers is

computed as the ratio between the number of picture elements in the fiber brightness range and the total number of picture elements. The volume fraction of fibers is assumed to equal the area fraction.

The image analysis technique was applied to graphite/epoxy specimens with fibers oriented at various angles with respect to the cross-sectional plane. The volume fractions of fibers estimated by the image-analysis method lay within 5 percent of those determined by the acid-digestion technique

over a volume-fraction range of 45 to 70 percent. The differences between the volume fractions of fibers estimated by the two methods are attributed to spatial variations of these fractions within the panels from which the specimens were cut.

This work was done by Michael Viens of Goddard Space Flight Center. For further information, write in 68 on the TSP Request Card.

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*Lewis Research Center,
Cleveland, Ohio*

Fiber-optic devices have been invented for use in measuring the locations of liquid drops and the levels of liquids in containers. These devices are essentially special-purpose rulers with illuminated fiducial marks, against which surfaces of liquids can be viewed with the help of magnifying glasses or microscopes.

A device of the present type includes an apparatus that launches light into an optical fiber at one end for illuminating a ruler at the other end. At the ruler end (see Figure 1), narrow crosswise grooves that serve as fiducial marks have been scored or milled into the fiber at specified measurement intervals. The tip of the fiber at this end is coated with an opaque or reflective material to prevent light from emerging from the tip and spuriously illuminating the adjacent liquid.

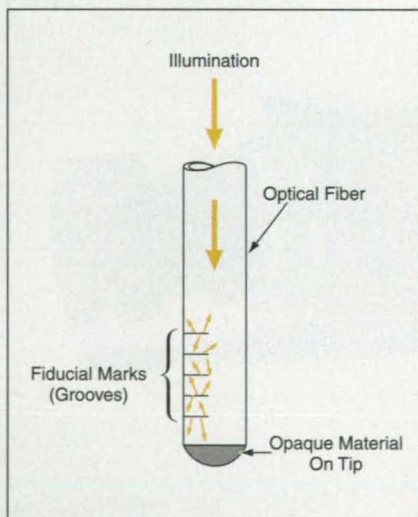


Figure 1. Grooves at Measurement Intervals near the tip of the optical fiber serve as fiducial marks.

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For proper functioning of the device, the index of refraction of the scored or milled outer layer(s) of the optical fiber must closely approximate the index of refraction of the liquid that one seeks to measure. In the absence of liquid, light is scattered from all the fiducial marks, making them appear to glow brightly. When liquid is in contact with a fiducial mark, the optical continuity afforded by matching of indices of refraction reduces or eliminates scattering of light, so that the fiducial mark no longer appears to glow brightly and possibly even becomes invisible. Thus, the surface of the liquid can be located to within the interval between a brightly illuminated fiducial mark and an adjacent darker (or even invisible) fiducial mark (see Figure 2).

The smallest increment of volume that can be measured depends on several factors, including the type of illumination (incoherent or coherent), propagation of light along the fiber in a single mode or multiple modes (greater precision may be possible in the coherent, single-mode case), and of course the cross-sectional area of the container in which the device is used. It has been estimated that volume increments as small as

tens of picoliters can be measured by use of devices of this type.

This work was done by DeVon Griffin of Sverdrup Technology Corp. for **Lewis Research Center**. For further information, **write in 80** on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-15926.

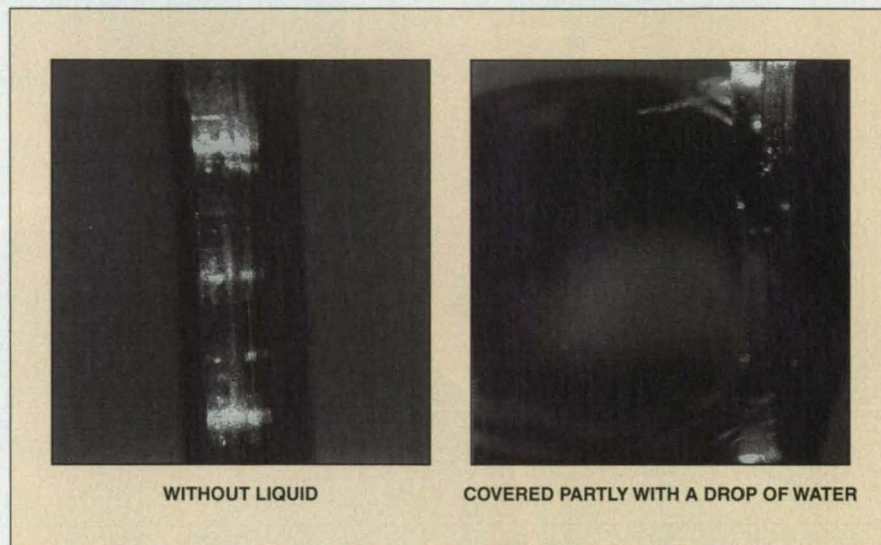


Figure 2. **Fiducial Marks at Intervals** of 1 mm scatter light and thus appear to glow in the absence of liquid, as shown in the left photograph (top view). The right photograph shows the same optical fiber covered partly with a drop of water (with gravitation perpendicular to the axis of the fiber), which renders the marks invisible.

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Measurements With a Laser- Speckle Strain Gauge

Lewis Research Center,
Cleveland, Ohio

Tests were run in which a laser-speckle strain gauge was used to measure strains on the surfaces of fibers under known tensile loads at room temperature. Further experiments were part of a continuing effort to develop a capability for noncontact measurement of strains in fibers at high temperatures. Overall, the laser-speckle strain gauge was found to be reliable for measuring strains in narrow fibers at room temperature, and there do not appear to be any insurmountable obstacles to extension of the measurement capability to high temperature.

This work was done by Lawrence G. Oberle, Lawrence C. Greer III, and John P. Barranger of **Lewis Research Center**, and Christian T. Lant of Sverdrup Technology, Inc. No further documentation is available. LEW-16014

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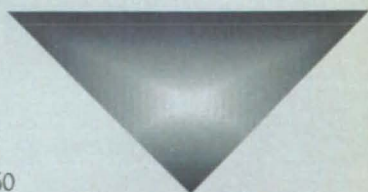
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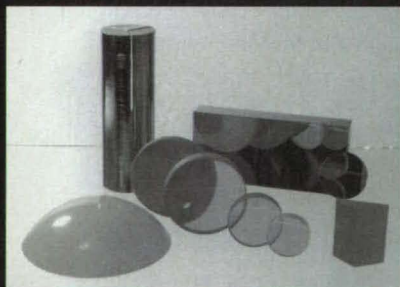
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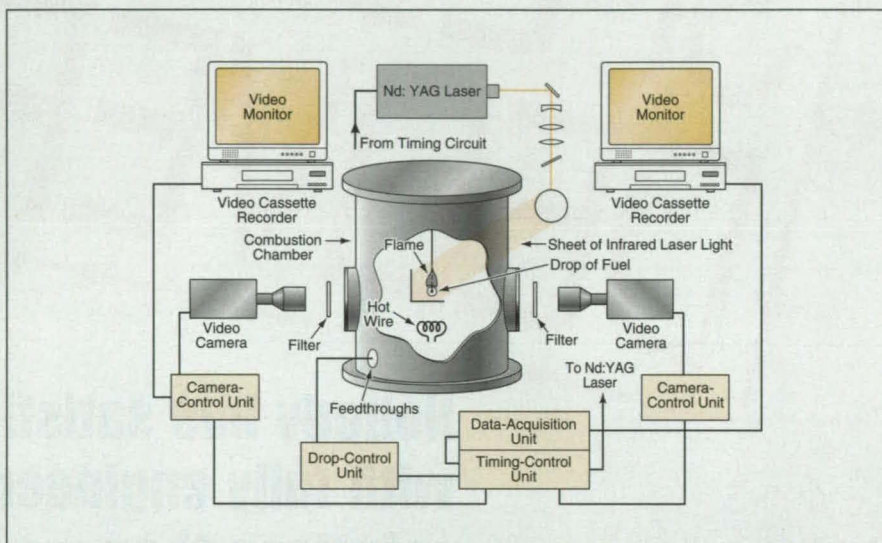
Laser-Induced Incandescence for Research on Combustion

Glowing soot particles reveal much about combustion processes.

Lewis Research Center, Cleveland, Ohio

The figure shows a laboratory apparatus that exploits laser-induced incandescence (LII) for research on combustion of sprayed liquid fuels. Aiming an infrared laser beam at a flame from a single burn-

The combustion process is observed by two video cameras through windows in the combustion chamber, and the video images are recorded on tape. Each camera is equipped with a different opti-



A Drop of Burning Fuel suspended in a combustion chamber is illuminated by a sheet of infrared light from a pulsed Nd:YAG laser. The infrared light quickly heats soot particles in the flame to a temperature of almost 4,000 K, causing emission of a distinctive blue light with intensity proportional to the concentration of soot.

ing drop of fuel, the apparatus radiatively heats the soot particles to make them glow distinctively, and measures the spatial and temporal distribution of the incandescence. The apparatus thereby obtains data on the spatial and temporal distribution of the concentration of soot in the flame. Such experimental study of the distribution of soot in the flame from a single drop of fuel provides data for testing and developing the theory of the complex interactions that occur in sprayed-fuel combustion chambers.

The drop of fuel to be observed has an initial diameter of about 1.5 mm and is suspended in the observation position on a bead at the lower end of a 230- μ m-diameter fiber that hangs vertically. The drop is ignited by a hot wire. A pulsed neodymium:yttrium aluminum garnet (Nd:YAG) laser generates the infrared beam at a wavelength of 1,064 nm. By use of lenses and mirrors, the beam is formed into a sheet of light and aimed slightly off the centerline of the fiber so as not to strike the fiber or drop but to pass near the fiber and drop so as to irradiate a planar region near the center of the flame.

cal filter so that together, the cameras obtain both natural images of the whole flame and LII images of the laser-irradiated region of the flame. The deployment and ignition of the drop of fuel and the timing of the laser, camera, and associated circuitry are controlled by an automated system that includes a computer and digital delay generators. The exposure time for the LII images is 100 ns.

The natural image shows primarily the light emitted by oxidizing soot, with both emission and absorption integrated along the line of sight. The LII image shows the distribution of both oxidizing and nonoxidizing soot in the laser-irradiated plane.

This work was done by Randall L. Vander Wal and Daniel L. Dietrich of Lewis Research Center. For further information, write in 81 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16078.

Heating via Optical Fibers for Control of Crystal Growth

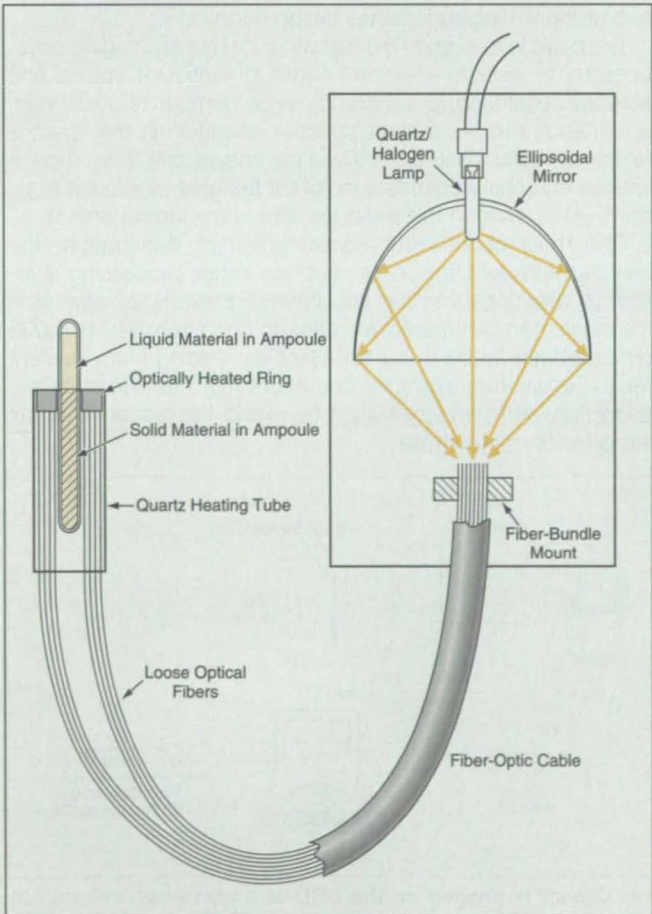
Better control of temperature might lead to production of better crystals.

Marshall Space Flight Center, Alabama

In an experimental method for growing a single crystal by directional solidification from a melt in an ampoule, the crystalline material in the ampoule is heated by thermal radiation generated by an external source and transmitted to the ampoule via a bundle of high-temperature optical fibers. The ampoule ends of the fibers are terminated in a cylindrical quartz heating head that surrounds the ampoule and that can be translated along the ampoule (see figure). The same or a different bundle of fibers can provide localized, translatable radiational cooling of the heated region.

The source can be a lamp or a laser. For operating temperatures above 1,000 °C, the fibers can be made of sapphire. The source ends of the fibers are arranged to accept radiation from the source, while the ampoule ends are arranged to provide axially localized, circumferentially evenly distributed heating or cooling of the material in the ampoule. The flexibility of the fibers allows translation of the heated region along the ampoule.

This method is undergoing development in an effort to obtain localized radiational heating and/or cooling with a precision not previously available except by use of relatively expensive and



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cumbersome equipment. This development is expected to yield an improved capability for precise control of crystal-growth temperatures, with consequent improvements in the qualities of single crystals.

This work was done by Stephen C. Bates of Thoughtventions Unlimited for Marshall Space Flight Center. For further information, write in 101 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26393.

Archaeological Applications of Advanced Imaging Techniques

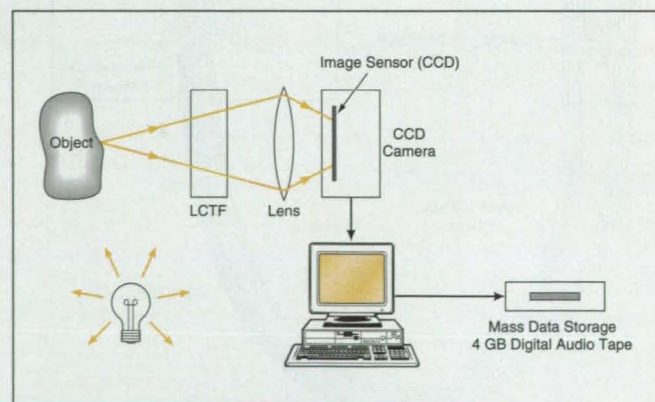
Multispectral imaging can be used to extract new information.

NASA's Jet Propulsion Laboratory,
Pasadena, California

Advanced multispectral electronic image-acquisition and image-processing techniques are beginning to make it possible to extract information that, until now, has been hidden in archaeological objects of interest. For example, a suitable combination of advanced imaging techniques can reveal ink residue in writing on an ancient manuscript, even when the writing is invisible to the unaided eye because the ink has faded or flaked off and/or the writing surface has become too dark.

The basic idea is to do the following: (1) Use an imaging spectrometer to acquire spectral images of sufficient spatial and spectral resolution (a sufficiently large number of pixels and, within each pixel, sufficient spectral resolution in the spectral region of interest) and (2) Process the image data to synthesize images that show contrasts to reveal features of interest (e.g., contrasts between ink residues and surrounding areas).

One must choose the wavelength(s) of illumination, the imaging wavelength band(s), and the image-processing algorithm(s) appropriate to the specimen. For example, viewing in the single narrow infrared wavelength band from 970 to 1,000 nm has been found to be excellent for reading many ancient texts. For another example, one might need to illuminate the specimen with ultraviolet light to excite fluorescence in ink ingredients or substrate.



The Object is imaged on the CCD at a wavelength selected by use of the LCTF, then the image data are digitized and stored. The process is repeated for all wavelength bands of interest to obtain a spectral image of the object.

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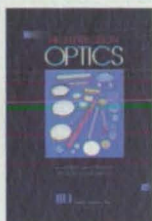


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A 128-page full-color catalog of "High-Performance Digital CCD Cameras" from Princeton Instruments outlines the company's line, with applications from microscopy to astronomy. The cooled slow-scan imaging CCD cameras have spectral response from x-ray to the near infrared. The catalog has specifications for the more than 30 CCD chips offered in the cameras, and application notes to help in selecting from the line. Princeton Instruments, Inc., 3660 Quakerbridge Road, Trenton, NJ 08619; (609) 587-9797; Fax: (609) 587-1970. <http://www.prinst.com>

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NESLAB Instruments Inc.

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The figure schematically illustrates a portable, table-top-size imaging spectrometer for use in the field. A liquid-crystal tunable filter (LCTF) is used as a variable-wavelength band-pass filter to select a wavelength band for imaging. The LCTF can be either in a set of two; one for the mostly visible wavelength range from 0.4 to 0.72 μm , and one for the mostly infrared range from 0.6 to 1.05 μm . An astronomical slow-scan cooled silicon charge-coupled-device (CCD) camera and computer-based electronic instrumentation are used to acquire and store spectral images. The CCD is sensitive out to 1.05 μm , well beyond the wavelength of the failing sensitivity of infrared film used heretofore.

Electronic imaging techniques offer several advantages over film photography in archaeology. Electronic images are available immediately; there is no delay for chemical processing or subsequent refocusing. A remotely situated editor could participate in an imaging session via television, guiding an imag-

ing technician in locating and imaging the features of interest. If, for example, a closeup image is needed, the imaging system can be adjusted on the spot to obtain the correct spatial detail. The editor can perform, or request that the imaging technician perform, any number of image-processing steps until the desired data have been obtained; this can help prevent the emergence of problems after the shooting session has been completed — a characteristic disadvantage of film photography. Digital imaging is also suitable for routine production; a considerable amount of text (or many objects) can be imaged and the images can be enhanced and made available for scholars in a short time. Providing images of the highest quality in a timely manner can enhance and accelerate scholarly publication.

This work was done by Gregory H. Bearman of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 100 on the TSP Request Card. NPO-19865

Hybrid Infrared Instrument for Measuring Surface Temperature

A boresighted FTIR spectrometer would provide a correction for water vapor.

NASA's Jet Propulsion Laboratory, Pasadena, California

A hybrid infrared instrument has been proposed for airborne or spaceborne use in mapping the instantaneous temperature on the surface of the Earth. The hybrid instrument would make it possible to retrieve surface temperatures with greater accu-

racy than can be obtained when using only a thermal-infrared-imaging radiometer developed previously for this purpose.

The proposal was made in response to an analysis of measurements taken with an airborne visible/infrared imaging spectrometer. The analysis revealed that of the unpredictable phenomena that affect radiometric measurements, the one that contributes the greatest amount of uncertainty to surface-temperature estimates is absorption and reemission of infrared radiation by water vapor in the atmosphere. Thus, it would be necessary to acquire concurrent data on the atmospheric water-vapor content along the line of sight in order to make the corresponding corrections to the surface-temperature estimates.

The required water-vapor data could be obtained by use of a Fourier-transform infrared (FTIR) spectrometer of modest design. Accordingly, the hybrid instrument would include the thermal-infrared-imaging radiometer used previously, plus the FTIR spectrometer, which would be boresighted toward

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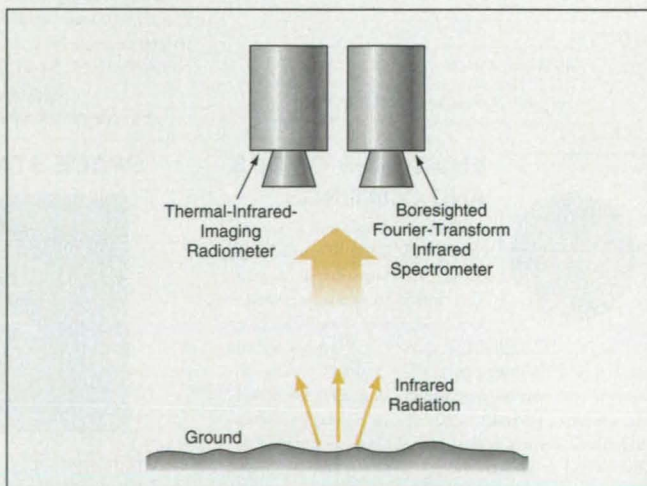
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The Airborne Imaging Radiometer and FTIR Spectrometer would be aimed at the same ground target to obtain data on surface temperature. The output of the FTIR spectrometer would provide a correction for the water-vapor content of the intervening atmosphere.

the same target as that observed by the radiometer (see figure). Computational simulations for some representative cases have shown that whereas surface-brightness-temperature errors attributable to atmospheric water vapor can be as large as tens of Kelvins, the root-mean-square error in surface brightness

temperature obtained with the hybrid instrument would be about 0.45 K.

This work was done by Thomas G. Chrien of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 102 on the TSP Request Card. NPO-19650

Program Simulates Effects of Radiation Damage in CCDs

Measures of degradation of performance are estimated probabilistically.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Charge-Coupled Device Radiation Damage Assessment (CCDPFA) computer program is a simulation program that utilizes the generic probabilistic failure assessment (PFA) methodology to evaluate degradation in the performances of charge-coupled devices as a consequence of exposure to radiation. CCDPFA can be used to compute CCD-performance-degradation sensitivities, the understanding of which contributes to efficiently making design tradeoffs while satisfying performance goals.

The CCD performance parameters characterized are charge-transfer efficiency (CTE) and signal-to-noise ratio (S/N). The CCD signal is derived from photon-flux spectrum and quantum-efficiency spectrum inputs. The radiation-environment input is in the form of a fluence spectrum for each radiation source considered. A transfer-curve methodology is used to compute CTE degradation and the effect of dark current on degradation in S/N.

CCDPFA is modular and includes routines for (1) computing signal, CTE, dark current, and S/N; and for (2) a statistical procedure called "bootstrapping," which is an efficient way to imbed the uncertainty in an empirical transfer curve within a simulation program. Also included is a routine for characterizing the bivariate distribution of the performance measures, CTE and S/N, from the simulated performance data, plus routines for generating values from uniform, normal, gamma, and beta probability distributions. An illustrative application is documented in order to demonstrate CCDPFA capabilities, using data collected for the Cassini camera, the Multi-Angle Imaging Spectro-Radiometer (MISR) and the Solar-A Soft X-Ray Telescope.

The generic PFA methodology combines engineering analysis with engineering assessment and modeling of uncertainty and any relevant test and opera-

tions experience in order to quantify performance. In this application, sources of uncertainty are the radiation environment, design parameters, and the transfer function. CCDPFA can be used at any time in the design, development, or operational phase of a program, using the information available.

CCDPFA is written in FORTRAN 77 to be machine-independent. A FORTRAN 77 compiler is required to build the executable code. A sample executable code for MS-DOS is provided. CCDPFA has been successfully implemented by COSMIC on IBM-compatible computers running MS-DOS 5.0 and Linux 1.1.59, a DEC MicroVAX 3600 computer running VMS 5.5-1, Sun4-series systems running SunOS 4.1.3 and Sun Solaris 5.4, a DECstation 3100 computer running DEC RISC ULTRIX 4.3, and an HP9000/705 computer running HP-UX 9.01. It may be necessary to adjust array sizes, depending on the applications; however, 2MB of main memory and 3MB of hard-disk space should be sufficient for most applications. The standard distribution medium for CCDPFA is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. When ordered on MS-DOS diskette, the contents of the diskette have been compressed by use of the PKWARE archiving software tools. The utility software to unarchive the files, PKUNZIP.EXE, is also included. CCDPFA was under development from 1993 through 1994, and is a copyrighted work with all copyright vested in NASA.

This program was written by Nicholas Moore, Donald Ebbeler, and Laura Newlin of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 11 on the TSP Request Card. NPO-19631

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Portable Sensors Would Locate Launching and Firing Sites

Advanced positioning techniques would be implemented in wristwatch-sized devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Small, portable optoelectronic sensors have been proposed for use in determining the latitudes, longitudes, and altitudes of missile, rocket, artillery, and mortar launching and firing sites in nearly real time. These sensors would detect flashes of visible and infrared light emitted from launches and firings; the sensors would be passive in the sense that unlike radar-based sensors, they would not emit probing beams of electromagnetic radiation that could be detected by enemy sensors. Approximately the size of a wristwatch, each sensor could easily be carried by a single person. These sensors would replace the large, heavy, power-hungry, trailer-mounted active-radar and optical/acoustical systems that are now used to detect launches and firings.

Each sensor would include an active-pixel array of photodetectors configured in a toroidal ring, an annular "fly's-eye" optic that would direct incoming light onto the array, an internal compass for reference to magnetic or true north, a Global Positioning System (GPS) receiver, and a microcomputer. From the location of the image of a flash on the array and from the position and orientation information supplied by the GPS receiver and compass, the microcomputer in each sensor would determine a

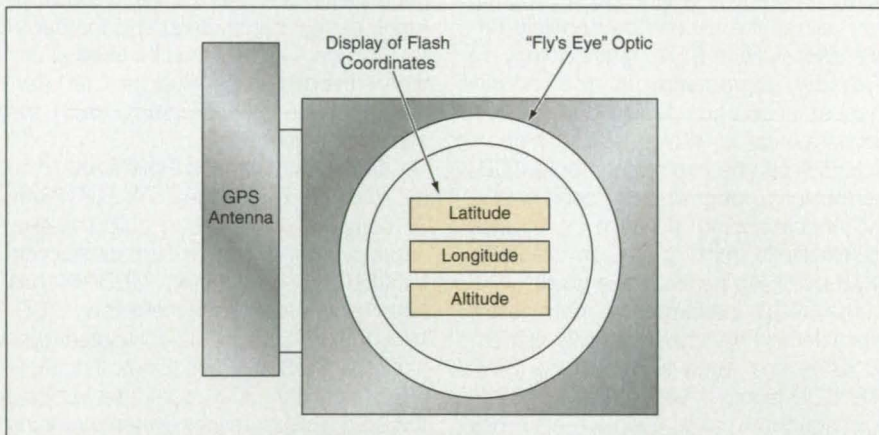
line that passed through that sensor and the location of the flash.

The proposed sensors would be operated in pairs, the sensors in each pair being deployed to different locations a known distance apart to obtain different directional fixes. One sensor in a pair would be designated as the primary sensor. The location of a flash could be identified as the intersection of the lines determined by the two sensors. The supporting sensor would transmit its information to the primary sensor, which would compute the coordinates

of the intersection, thereby locating the source of the flash in three dimensions.

The use of the proposed sensors could also extend to the detection of forest fires. Flame "hot spots" could be identified, and fires initiated by lightning could be recognized early.

This work was done by Philip I. Moynihan and Maurice L. Langevin of Caltech for NASA's Jet Propulsion Laboratory. For further information, write in 10 on the TSP Request Card. NPO-19757



The **Flash Sensor** would determine its own position plus the direction of a line along which a flash of light arrived. The intersection of two such lines from two such sensors would be computed by the "primary" sensor and assumed to be the location of the source of the flash.

Sapphire Fiber-Optic Endoscopes for High Temperatures

Instruments would provide images of combustion processes.

Lewis Research Center, Cleveland, Ohio

Endoscopes made with coherent bundles of sapphire optical fibers have been proposed. These endoscopes are intended for use in experimental research on combustion and flow phenomena in developmental high-temperature engines, and in monitoring and controlling the operation of such engines. The optical outputs of these endoscopes would be fed to video cameras to generate video images of the phenomena of interest. The digitized image data could also be processed to extract quantitative data on the phenomena.

These endoscopes would function in the same manner as do commercial

endoscopes made for lower temperatures. However, these endoscopes would exploit recent advances in the fabrication of bundles of sapphire optical fibers that are suitable for imaging and can withstand high temperatures. In an experiment to demonstrate feasibility, a prototype bundle of 100 sapphire fibers, each 100 μm in diameter was used to obtain a video image of a scene at a temperature of 1,000 $^{\circ}\text{C}$. For a typical future application, a bundle of many more narrower fibers potted for survival at high temperature along with a high temperature lens could be coupled where the temperature is lower to

a glass fiber bundle and a standard video camera to create an endoscope with a use temperature as high as 1,500 $^{\circ}\text{C}$.

This work was done by Stephen C. Bates of Thoughtventions Unlimited for Lewis Research Center. For further information, write in 5 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16227.



Mathematics and Information Sciences

Multiple Turbo Codes for Deep-Space Communications

A report proposes a method of coding and decoding for deep-space communications. The method is based on the same turbo-code concept as that described in "Turbo Coding and Decoding for Personal Communications" (NPO-19634) elsewhere in this issue of *NASA Tech Briefs*. The report introduces multiple turbo codes and a suitable decoder structure derived from an approximation to the maximum a posteriori probability decision rule; this decoder structure is parallel, whereas that of the original turbo decoder scheme for the two-code case is pure serial.

This work was done by Dariush Divsalar and Fabrizio Pollara of Caltech for **NASA's Jet Propulsion Laboratory**. To obtain a copy of the report, "Multiple Turbo Codes for Deep-Space Communications," write in 19 on the TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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California Institute of Technology
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Refer to NPO-19635, volume and number of this *NASA Tech Briefs* issue, and the page number.

GaAs; the outer contact layers are made of GaAs doped to 10^{18} cm^{-3} . Unlike in the first device, the outer two undoped 500-Å-thick layers in the second device serve as spacer layers between the outer two quantum wells and the outer doped contact layers. The report discusses the foregoing and related matters, including the fabrication and testing of the devices. The results of the tests confirm expectations; the dark current of the second device was found to be of the order of 10^{-5} to

10^{-4} that of the first device at temperatures up to 60 K.

This work was done by Sarath Gunapala, True-Lon Lin, and Jin S. Park of Caltech for **NASA's Jet Propulsion Laboratory**. To obtain a copy of the report, "Dark Current Reduction by Spacer Layers," write in 29 on the TSP Request Card.
NPO-19426

(continued on page 160)

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Reducing Dark Currents in $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$ Quantum-Well Devices

A report presents a discussion of two $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$ quantum-well infrared photodetector devices. The quantum-well layer configuration of one of the devices comprises five 80-Å-thick $\text{In}_{0.15}\text{Ga}_{0.85}\text{As}$ quantum-well layers doped to $5 \times 10^{17} \text{ cm}^{-3}$, separated by 500-Å-thick quantum-barrier layers of undoped

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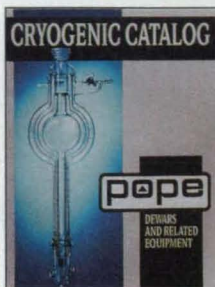


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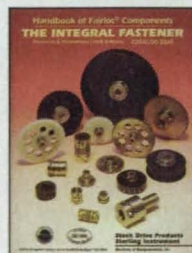
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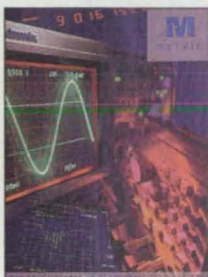


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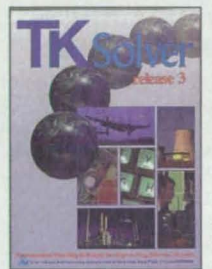


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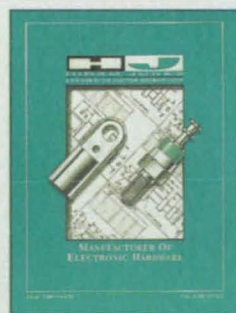


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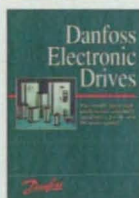


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PMI's Windows-based Envelope Surface Area Analyzer (WESA) offers a simple, quick, and reliable method for obtaining the envelope surface area of a powder by using the flow permeametry technique. WESA uses accurate, state-of-the-art flow control with no special gases or liquid nitrogen required. The analyzer is controlled by user-friendly Windows-based software, which provides user interface and dialog boxes when needed. Porous Materials, Inc., 83 Brown Rd., Ithaca, NY 14850; Tel: 607-257-5544 or 800-TALK-PMI; Fax: 607-257-5639; E-mail: info@pmiapp.com; URL: <http://www.pmiapp.com>.

Porous Materials, Inc.

For More Information Write In No. 317

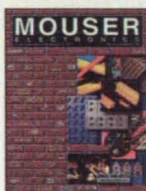


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A new Danfoss catalog provides an overview of the VLT 2000, VLT 3000 and VLT 3500 Series AC drives (spanning 1/2 to 300 HP); AC controls; Cycletrol Series DC controls; VanSpeed DC adjustable speed controls; and RDS-20 DC adjustable speed controls. An AC Technical Reference section reviews AC motor technology and adjustable frequency drive technology; and a DC Technical Reference reviews DC motor/drive technology. Danfoss Electronic Drives, Division of Danfoss, Inc., 2995 Eastrock Drive, Rockford, IL 61109; Tel: 800-432-6367; Fax: 815-398-2869.

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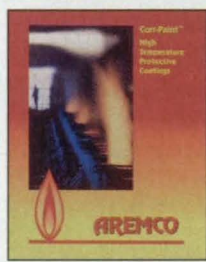
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Goodfellow Corp.

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Aremco Products, Inc.

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Integrated Systems Inc.

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Omega Engineering, Inc.

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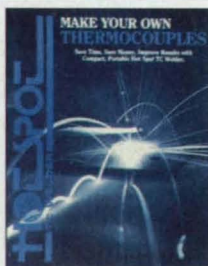


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Entran Devices, Inc.

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DCC Corp.

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PRESSURE TRANSDUCERS/TRANSMITTERS

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Omega Shielding Products Inc.

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Smalley Steel Ring Co.

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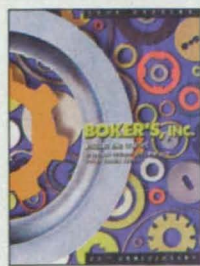


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Advanced Pressure Products

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Adaptive Research

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Advanced Pressure Products

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MULTICHANNEL DATA ACQUISITION SYSTEM

ScannerPlus® includes local display, local control capabilities, advanced math computations, and data communications capabilities. Optional proprietary software packages from Azonix include SCANCAL, which allows users to calibrate a ScannerPlus and sensors together as a system; and EZSCAN, an easy-to-use software package for configuring a ScannerPlus with a PC. Typical applications include utilities, pharmaceutical, in-vehicle testing, and any application that can benefit from comprehensive I/O interface and on-board computational and control capabilities. Azonix Corporation, 900 Middlesex Turnpike, Bldg. 6, Billerica, MA 01821; 800-365-1663 or 508-670-6300; Fax: 508-670-8855.

Azonix Corporation

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Machida, Incorporated

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1997 ELECTRONIC HARDWARE CATALOG

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Globe Electronic Hardware, Inc.

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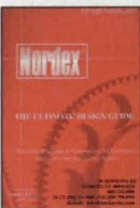


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Ball Screws & Actuators Co., Inc.

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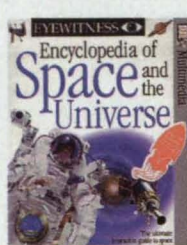


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For More Information Write In No. 350



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National Electrostatics Corp.

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Algor's Internet place has detailed information on four product lines. Discover Houdini, Algor's automatic CAD solid model to 8-node "brick" mesh converter. Learn about Algor FEA, including case histories. Preview engineering videos, books and multimedia. See all new integrated piping/vessel/plant design software. If you do not have Internet access, call for free info. Algor, Inc.; E-mail: info@algor.com; URL: http://www.algor.com; Tel: 412-967-2700; Fax: 412-967-2781.

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NEW KIND OF MULTIMEDIA VIDEO TEACHES FEA LESSONS

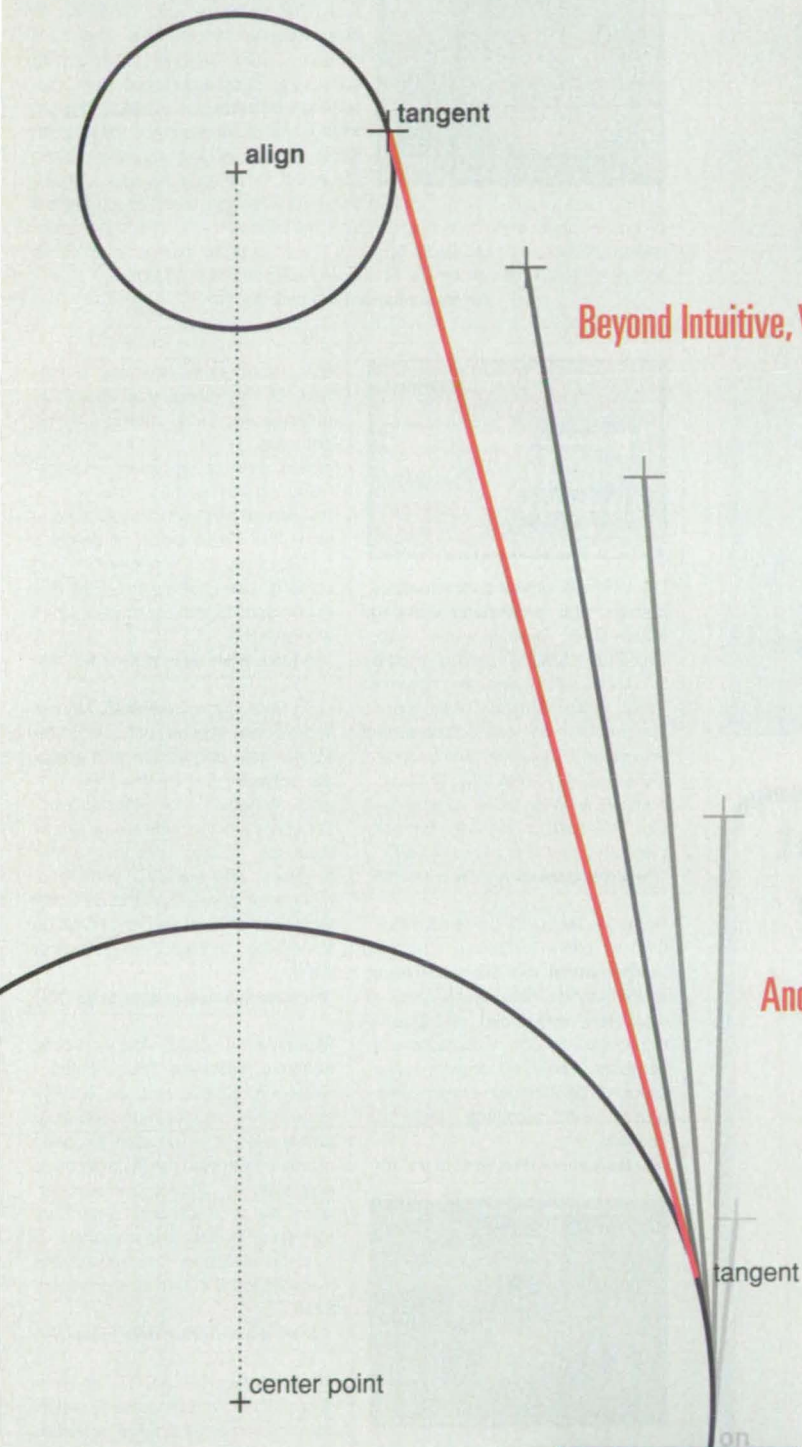
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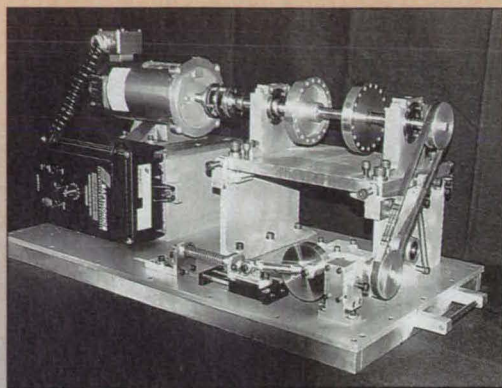
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Testing Equipment

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Nondestructive Test Equipment (pictured: test block)



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(pictured: Series 3210)



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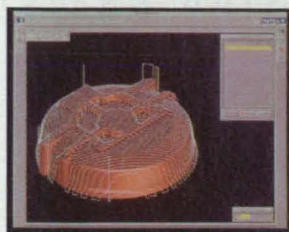
ATS APPLIED TEST SYSTEMS, INC.

Phone: 412/283-1212, Fax: 412/283-6570
Online: <http://www.atspa.com>

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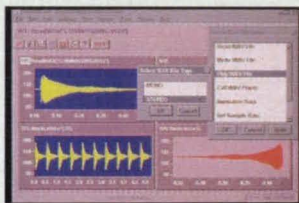
New on Disk

Product of the Month



Matra Datavision, Andover, MA, has introduced Euclid Quantum CAD/CAM/CAE and PDM software suite based on an object-oriented architecture. The suite includes Euclid Designer 3D modeling software for designers in concurrent engineering environments; Euclid Analyst, a what-if analysis environment for in-depth simulation and model preparation; Euclid Machinist, for creating the best machining tool path for a part model; and Euclid Design Manager, which integrates and processes engineering data at all stages of the process cycle. The four environments are linked through Euclid Desktop, which accesses external applications and provides for data exchange. Package pricing begins at \$9,900.

For More Information Write In No. 703



DADISP/WAV digital audio analysis, display, and processing software from DSP Development Corp., Cambridge, MA, is an add-on module to DADISP data analysis software. Digital audio data from WAV format files can be read, written, and edited via one-line functions. The program allows users to call any Windows-compatible WAV player device and play WAV data on any WAV-compatible sound card. It is priced at \$495.

For More Information Write In No. 705

Universal Technical Systems, Rockford, IL, offers TK Solver Release 3 mathematical modeling software, which handles data relationships in equations, units, tables, and graphs. It provides results in spreadsheet, database, and CAD drawing applications. The Windows program integrates with intranets and the Internet.

For More Information Write In No. 701



Version 11.0 of Camand® CAM software from Structural Dynamics Research Corp., Milford, OH, includes enhanced multiple surface fillet construction, and an improved online documentation viewer. The program enables complex-surface modeling and 3- through 5-axis machining in mold and die work, as well as piece-part manufacturing.

For More Information Write In No. 702

B.A. Intelligence Networks, Southfield, MI, has announced BaanPDM engineering and manufacturing software, which provides an integrated suite of document management, versioning, and change control, as well as product structure and work flow management. It operates on Windows and Windows-NT, and on Sun, Hewlett-Packard, IBM RS-6000, and Digital Equipment UNIX workstations.

For More Information Write In No. 706

HEM Data Corp., Southfield, MI, has announced version 3.1 of SnapMaster data acquisition and analysis software for Windows 95, 3.1, and Windows for Workgroups. Enhancements include a new sensor database, 12 logic functions, 18 filter functions, and standard arithmetic, trigonometric, calculus, and statistical functions. It is available in various standalone modules; pricing starts at \$495.

For More Information Write In No. 704

Experimental Data Analyst data analysis software from Wolfram Research, Champaign, IL, enables data-fitting, visualization, and error propagation. It allows users to obtain estimated errors in the fit parameters and examine graphical information about the fit. ASCII and binary data can be imported and exported. It runs on Windows, Macintosh, and many workstation platforms and costs \$495.

For More Information Write In No. 700

CNC Software, Tolland, CT, has introduced Windows-compatible Mastercam Version 6 CAD/CAM software for two- through five-axis milling, turning, two- and four-axis wire EDM, 3D design, drafting, and surface modeling. Built-in bidirectional translators include IGES, VDA, DXF, and ASCII. New features such as multi-surface manipulation tools, multiple-surface radial cutting machining, and rotating, panning, and zooming of shaded images are included.

For More Information Write In No. 707

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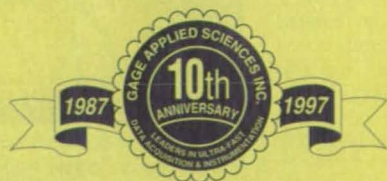


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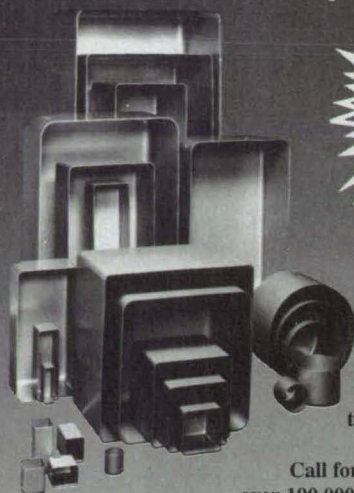
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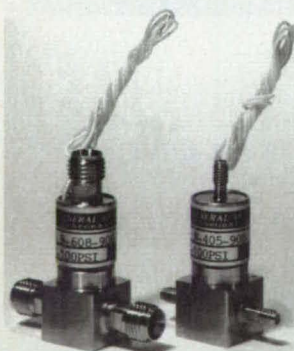
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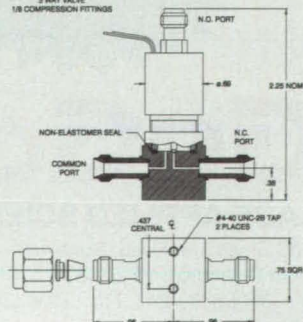
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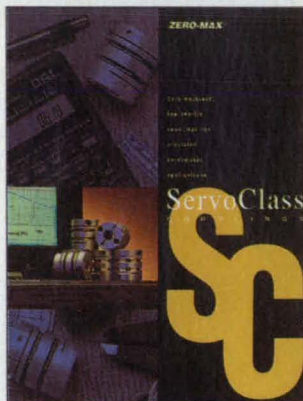
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For More Information Write In No. 448

New Literature



A six-page catalog of ServoClass™
couplings is available from Zero-Max,
Minneapolis, MN. Features include
zero backlash, high torsional stiffness,
low inertia, and integral keyless clamp
style mounting.

For More Information Write In No. 715

Ross Engineering Corp., Campbell,
CA, offers a four-page brochure of
high-voltage devices. Included are
HV relays, switches, and controls;
energy storage drivers; HV acces-
sories; and corona-reducing spheres
and toroids.

For More Information Write In No. 713



Advance Power, Solon, OH, has
released a 240-page catalog of
power supplies and related compo-
nents. Included are AC/DC, DC/DC,
and DC/AC converters, rectifiers, low-
voltage disconnects, and inverters.

For More Information Write In No. 710

Ceramco, Center Conway, NH, offers
a four-page brochure on custom
ceramic components produced by
low-pressure injection molding.
Tooling, machining, quality control,
and other capabilities are included.

For More Information Write In No. 717

Intelligence Instrumentation, Tucson,
AZ, has released a 32-page catalog of
data access hardware and soft-
ware for data acquisition, test and
measurement, process monitoring
and control, data collection, and
operator interface applications.

For More Information Write In No. 714



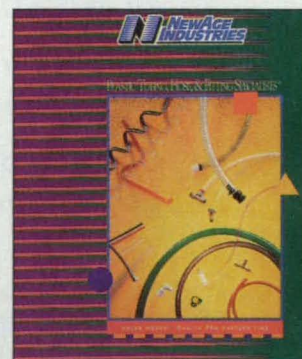
A 20-page catalog from Oregon Micro
Systems, Beaverton, OR, describes
precision motion controls. Applica-
tion programming, software support,
and condensed controller, accessory,
and driver specifications are included.

For More Information Write In No. 716



A 12-page brochure of Ce-marked
single-axis stepper and servo sys-
tems is available from Parker Hannifin
Corp., Compumotor Division, Rohnert
Park, CA. The PD-E ministep drive
and BD-E brushless servosystem
provide self-contained motion control.

For More Information Write In No. 712



The 124-page Technical Reference
Guide 8, featuring plastic tubing and
hose products, fittings, acces-
sories, and services, is available from
NewAge Industries, Plastics Technol-
ogy Group, Willow Grove, PA. Avail-
able materials include PVC, polyurethane,
nylon, Teflon®, Viton®, latex, and silicone.

For More Information Write In No. 711

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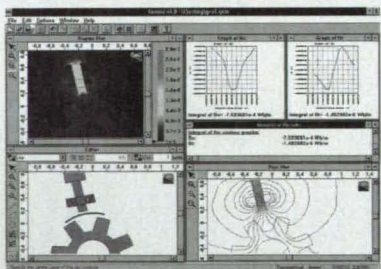


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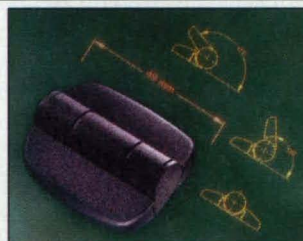


Sigma Interactive Solutions Corp., Fremont, CA, has announced a family of high-capacity fault tolerant disk array **RAID subsystems** for high-speed computer network servers, mission-critical computer data storage applications, and digital image processing systems. Based on the standard Fast SCSI-2 interface, they offer capacities ranging from 4 GB to 10 GB, and can operate at data transfer rates as high as 10MB per second. Using 3.5" disk drives, they can be installed in any PC or tower system with a 5.25" drive bay.

For More Information Write In No. 729

Tesa Measurement Systems, Novi, MI, has introduced the CM-9000 **non-contact gaging system**, which measures any shape or size of materials such as plastics, rubbers, metals, ceramics, or composites. The multi-axis measuring system features 2D, 3D, and rotary axis measurement, laser height measurement, image processing, automatic edge detection, and conventional and scanning touch probes.

For More Information Write In No. 733



Southco, Concordville, PA, offers the Positioning-Advantage **hinge**, which holds a door or panel open at two detent angles – 120° and 170° – without the use of secondary mechanical supports such as door stays or gas springs. It features a -10° detent angle and snap-on covers in a textured, matte black finish. The hinge is used where doors must remain in an open position or where hands-free access is required.

For More Information Write In No. 731

Fluorotherm Polymers, East Hanover, NJ, offers standard-stock **extruded rods** in a variety of fluoropolymers, including Kynar® PVDF, Teflon® PFA, FEP, Halar® ECTFE, Kel-F PCTFE, and Tefzel ETFE. Standard sizes range from 1/16" to 1-3/4". Sizes up to 2-1/2" also are available.

For More Information Write In No. 723



The TDS 510A **digitizing storage oscilloscope** from Tektronix, Beaverton, OR, provides four input channels, 500 MS/s maximum sample rate, and 50K record length. It features a TekProbe™ interface, direct on-screen reading of current and power in engineering units, a standard integral floppy disk drive, and trigger modes such as logic, pulse, and video. A full-bandwidth probe for every input channel is standard.

For More Information Write In No. 732



The VR Surfer from VRex, Hawthorne, NY, is a wireless **stereo 3D system** that works with computers and televisions. The technology enables the left and right eyes to see two separate views of the same object at the same time, creating the illusion of depth. The VR Surfer General Pack consists of lightweight 3D eyewear, an infrared transmitter, 3D videotape, and CD-ROM DOS- and Windows-based application software that enables users to adapt charts, graphs, and images created in Excel, Word, Powerpoint, and Autodesk 3D Studio.

For More Information Write In No. 734

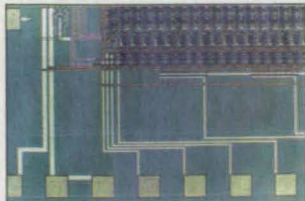
The RPW-410I **rugged portable workstation** from Datametrics Technology Systems Corp., Woodland Hills, CA, is housed in a modular chassis and features a drop-down, full-size keyboard and a 10.4" or 12.1" active matrix color display screen. AC/DC/battery power options, floppy drive, removable hard drive, CD-ROM, and PCMCIA slots are included. The unit uses an Intel Pentium or 486 processor CPU.

For More Information Write In No. 721

The SP8538 micropower sampling 12-bit **analog/digital converter** from Sipex Corp., Billerica, MA, features low power consumption, single-supply operation, and 3- or 4-wire synchronous serial interface. Programmable input configuration allows the analog information to be converted into one channel full differential or 2 channel single-ended. It is suitable for battery operated systems, portable data acquisition instrumentation, and remote sensing applications.

For More Information Write In No. 730

New on the Market



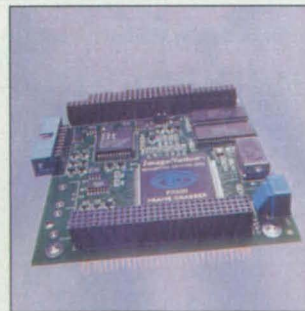
Amain Electronics, West Hills, CA, has introduced an all-digital focal plane **readout sensor device** based on Multiplexed Oversample Analog to Digital converter (MOSAD) technology. Designed to support HgCdTe and InSb detector arrays on 40 micron or larger centers, it produces a digital output at each pixel. The existing array size of 64 x 64 can be expanded.

For More Information Write In No. 720



Hewlett-Packard, Palo Alto, CA, has introduced the HP 54616C color **dual-channel oscilloscope**, which features 2-Gsample/s sample rate, 500MHz bandwidth, 1-ns peak detect, and 5K memory depth. Three-processor architecture allows storage and recall for up to 16 scope setups. An optional HP BenchLink/scope Windows-based software package allows images and data to be transferred to a PC.

For More Information Write In No. 724



Imagination Corp., Beaverton, OR, has announced the PX104-Plus **frame grabber** for machine vision applications. It provides continuous, triggered, or software-initiated frame capture with PCI-bus compatibility and captures up to 131 Mb per second to system RAM or VGA display. Software supports 16-bit DOS and Windows 3.1, 32-bit Windows 95 and Windows NT, and is compatible with Visual Basic and C/C++ compilers from Borland and Microsoft.

For More Information Write In No. 725

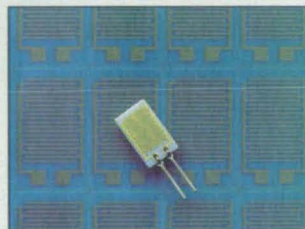


The P195 **pressure transducer** from Kavlico, Moorpark, CA, utilizes patented ceramic capacitive sensing technology for use in hydraulic control systems, test equipment, and industrial pressure measurement applications. It is available in pressure ranges from 0-1500 to 0-3000 psia/psig and provides an amplified voltage output while operating on 5 VDC.

For More Information Write In No. 726

Logic Beach, La Mesa, CA, offers the HyperLogger™ **portable data loggers**, which use Microsoft Windows-based software for system configuration, data analysis, and graphic data display. The standalone, battery-powered system features multi-channel and multi-axis graphs, and features 24 channels of analog and/or digital data stored on board for display on a PC.

For More Information Write In No. 727



Phys-Chem Scientific Corp., New York, NY, has introduced the EMD-2000 interchangeable **relative humidity transducer**, which measures 0.3" x 0.5" x 0.03", and is composed of an interdigitated gold terminal on an alumina substrate overcoated with a thermosetting hydrophilic polymer. It is suitable for use in 0-100% RH environments at temperatures from -40 °C to 100 °C.

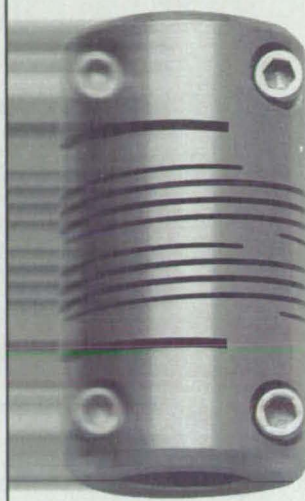
For More Information Write In No. 728



The EPE/EPX Series of low- and high-range **pressure sensors** from Entran Devices, Fairfield, NJ, provides static and dynamic measurements in a range of environments. High-pressure units are available in a rugged stainless steel housing and diaphragm. Operating temperatures range from -40 °C to 220 °C.

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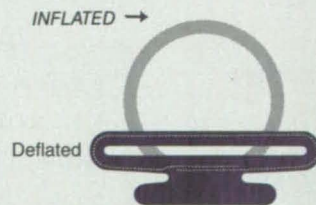
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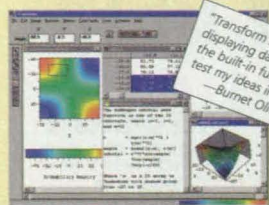
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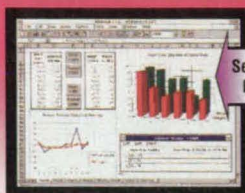
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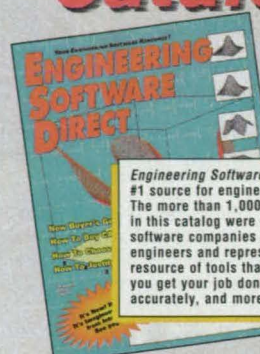
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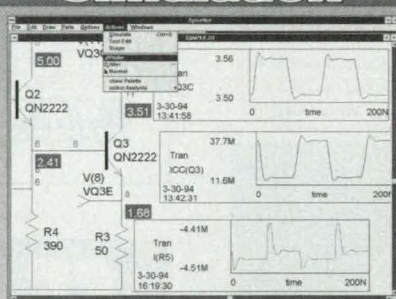
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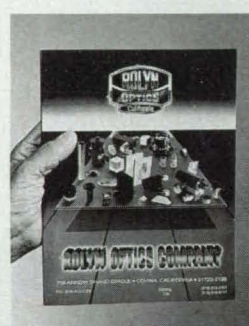
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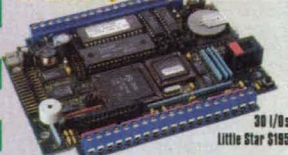
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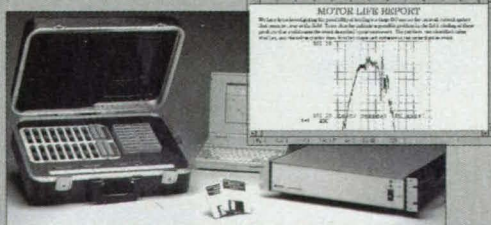
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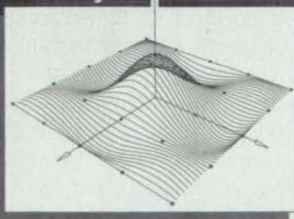
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Electronic Components and Circuits

Lightweight, Flexible, Thin-Film Solar Cells for Spacecraft

A report describes a program of research and development regarding thin-film, lightweight solar cells based on polycrystalline CuInSe_2 . According to the report, thin-film solar cells made of CuInSe_2 and related compounds have already been demonstrated to exhibit active-area conversion efficiencies as large as 16.4 percent in terrestrial settings, and the program was directed toward development of lightweight, flexible, thin-film CuInSe_2 -based cells that would exhibit comparable efficiencies and would be suitable for use aboard spacecraft.

This work was done by Bülent M. Basol, Vijay K. Kapur, Andrew J. Minnick, Craig R. Leidholm, and Arvind T. Halani of International Solar Electric Technology for Lewis Research Center. To obtain a copy of the report, "Light-Weight, Flexible Thin Film Solar Cells For Space Applications," write in 7 on the TSP Request Card.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16340.



Machinery/Automation

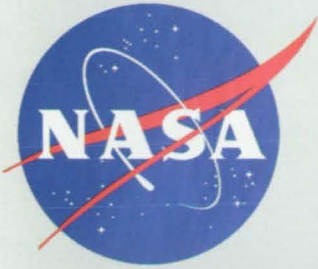
Update on Reducing Blade-Slap Noise From Rotorcraft

A report comprises the main text and illustrations of U. S. Patent 5,478,029, which pertains to mechanisms based on the principle of altering the balance of forces to tilt a lifting rotor in such a way as to increase the flow of air through the disk swept out by the rotor blades.

This work was done by Frederic H. Schmitz of Ames Research Center. To obtain a copy of the report, "Rotorcraft Blade-Vortex Interaction Controller," write in 98 on the TSP Request Card.

This invention has been patented by NASA (U.S. Patent No. 5,478,029). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-11992.

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